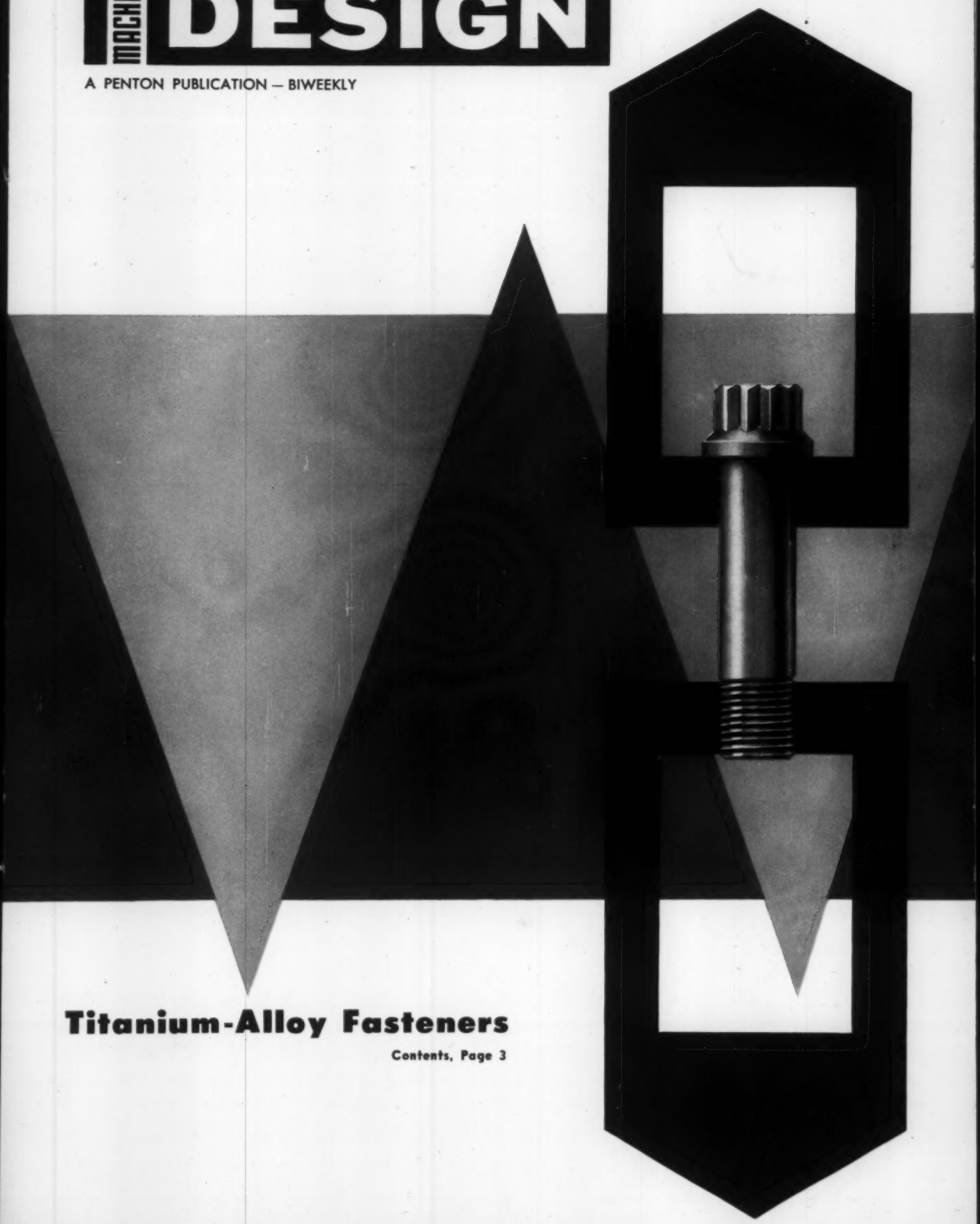
JANUARY 23, 1958

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



Titanium-Alloy Fasteners

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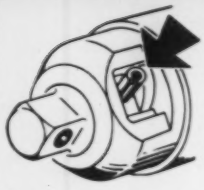
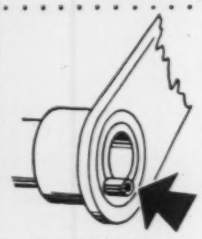
Rollpin® replaces 12 different fasteners

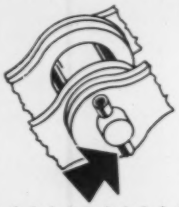


REPLACING A GROOVED PIN . . . in this application, Rollpin serves as a stop pin in a ratchet-wrench adaptor. Witl its light weight and high shea. strength, Rollpin functions perfectly . . . cuts assembly costs.



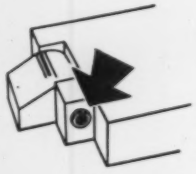
REPLACING A KEY . . . Rollpin demonstrates its ability to do away with precision tolerances, in this heating system damper arm. Faster, cheaper and more satisfactory than previous assemblies.

REPLACING A RIVET SHAFT . . . Rollpin serves as an axle for the sparkwheel of a cigarette lighter. No riveting or threading necessary . . . faster assembly. Note flush, clean fit.

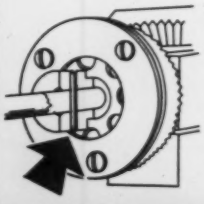


REPLACING A COTTER PIN . . . Rollpin assembly time is shorter, service life ten times longer. Vibration-proof flush fit. Easily removable.

REPLACING A SET SCREW . . . to fasten automobile brake handle a short length Rollpin is self-retained in the hand grip but can easily be driven into over-drilled hole in shaft for simple handle removal.

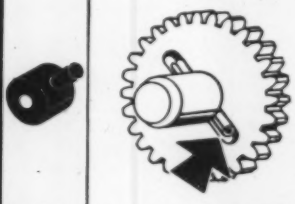


REPLACING A CLEVIS PIN . . . here Rollpin holds firmly in clevis, permits free action of moving member. Rollpin application shown is the plate of a home workshop tool.

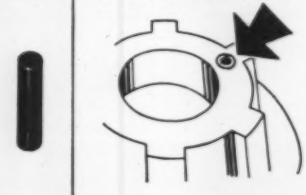


REPLACING TAPER PINS . . . in the assembly of precision differentials eliminated cost of taper pin reamers and the entire reaming operation. Rollpin costs less than a taper pin and installation is cheaper. They remove easily.

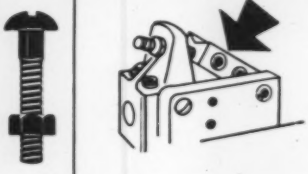
REPLACING A HEADED PIN . . . in this hinge pin application, Rollpin is simply and inexpensively driven in place, greatly reducing assembly costs. Constant spring tension holds Rollpin firmly in place . . . eliminates loosening of hinge due to wear.



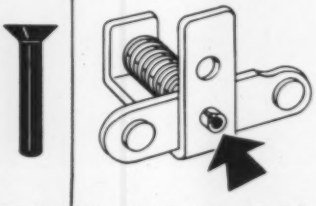
REPLACING A HUB ON A GEAR . . . Rollpin, self-retained in shaft, is simply snapped into molded slot to position sintered gear. This application, by an office equipment manufacturer, effects major savings in assembly. Rollpin's high shear strength is particularly valuable here.



REPLACING A DOWEL PIN . . . Rollpin is used here to prevent rotation of a thrust bearing. No reaming, no special locking. Easily removed. Lowest possible dowel pin cost.



REPLACING A BOLT AND NUT . . . Rollpins act as fasteners and pivots for the linkages in this electric welder. Rollpins may be used with a free fit in outer or inner members depending upon product design requirements.



REPLACING A RIVET . . . Rollpin serves as guide shaft for spring-loaded electrical interlock contacts. This electrical equipment manufacturer reports that rivet failure previously occurred at the clinched end under normal operating impact and vibration.

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Rollpin is the slotted tubular steel pin with chamfered ends that is cutting production and maintenance costs in every class of industry.

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- Delivers exact amount of lubricant to bearing.

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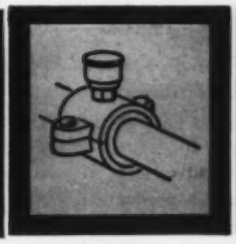
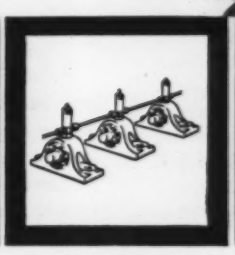
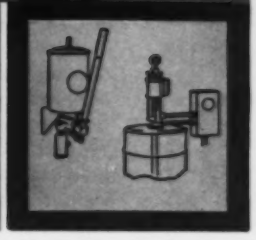


1. Remove grease cups or grease fittings.



2. Connect Accumatic fittings with copper tubing.

3. Connect sliding, rotary or oscillating parts into tubing system.



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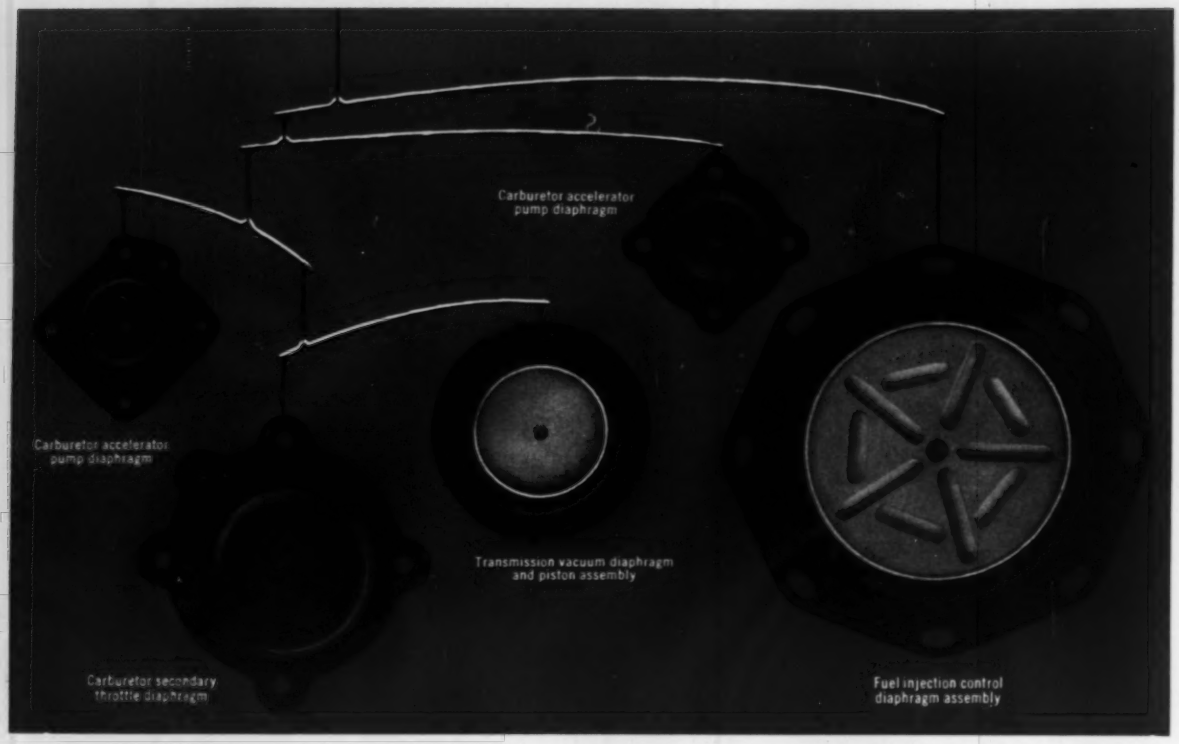
Carburetor accelerator pump diaphragm
Carburetor accelerator pump diaphragm
Transmission vacuum diaphragm and piston assembly
Carburetor secondary throttle diaphragm
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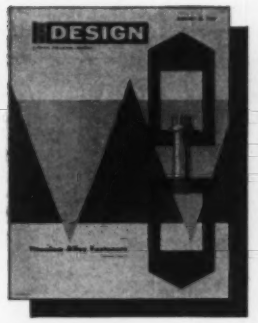

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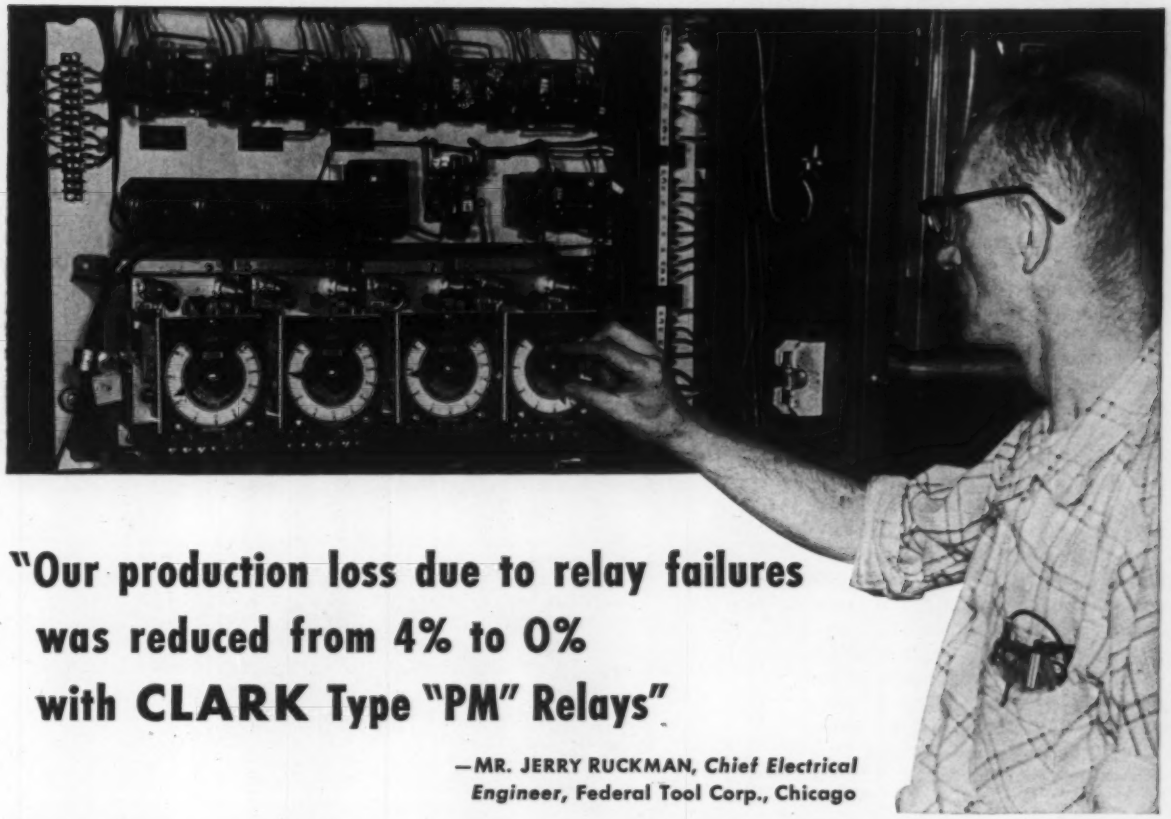


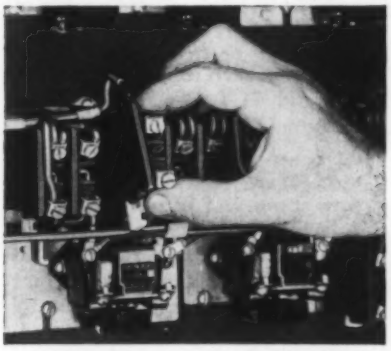
"Our production loss due to relay failures was reduced from 4% to 0% with CLARK Type "PM" Relays"

—MR. JERRY RUCKMAN, *Chief Electrical Engineer*, Federal Tool Corp., Chicago

Explains Chief Engineer Ruckman: "We turn out plastic housewares, haircurlers, toys, premiums and other plastic products by the hundreds of thousands every twenty-four hours. Demand is high. Customers insist on prompt delivery. That's why we were so concerned over the erratic operation of the relays in our molding machine control panels—the heart of our production line.

"We found that non-conductive plastic dust was collecting on the relay contacts, causing them to fail. When this happened, production was halted. Losses amounted to four percent.

"Two years ago we installed Clark Type PM relays, in which each set of contacts is shielded by its own melamine housing. Production stoppages from plastic dust have been cut to zero."



The unique sectional pole construction of the Clark Type "PM" relay offers many other important advantages

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National Engineers' Week Due for Big Send-Off

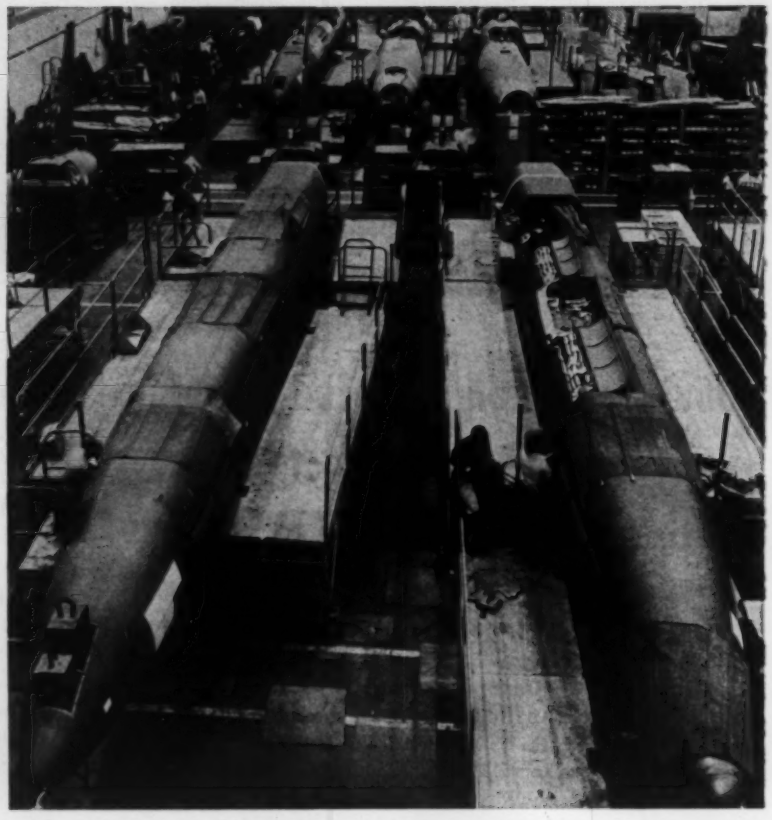
Killian, Kettering, Rickover Will Lead

WASHINGTON — With the public, Congress, and the press clamoring for greater scientific efforts, the 1958 National Engineer's Week, Feb. 16-22, is due for a warm reception. The list of sponsors has been announced by John L. Bahr, national chairman of the observance held each year during Washington's birthday week under the general sponsorship of the National Society of Professional Engineers.

James R. Killian Jr., special assistant to President Eisenhower for science and technology, will serve as one of 14 individual sponsors, as will Charles F. Kettering, General Motors Corp., Rear Admiral H. G. Rickover, chief of naval reactors for the AEC, and Allen B. DuMont, chairman of the board, Allen B. DuMont Laboratories Inc. Theme for the week will be "Engineering Builds Broader Horizons."

Purpose of the Week is to call attention to the contributions of the engineering profession. Early reports point to broader-than-ever participation in activities by industries and individual engineers.

A set of five one-minute, animated films will be shown in public-service spots on TV. One covers engineering in general and the others pay specific tributes to civil, mechanical, electrical, and chemical engineers.



PRODUCTION-LINE SNARKS in this recently released photograph will soon join operational units of the Strategic Air Command. Produced by Northrop Aircraft, the 5000-mile Snark is the first U. S. intercontinental guided missile. Although its cruising speed of Mach 0.9 is a fraction of the speed of an ICBM, the well-tested air breather has several distinct advantages. It can take evasive action, is extremely accurate—Snark's celestial-inertial guidance system weighs 1000 lb—and can be fired from a mobile platform in a relatively short time. The big missile resembles an airplane in looks and size: Wingspan is 42 ft; length, 74 ft; weight, 38,000 lb.

Display Computer Plots Targets At Speeds Above Mach 20

Used with Tracking Radar, Displays Missiles Flight

NEW YORK—A special target display computer will be supplied to the National Advisory Committee for Aeronautics for use with tracking radar systems. The computer is capable of plotting flight paths of test vehicles at speeds in excess of Mach 20.

The radar plotting computer, produced by Mid-Century Instrumatic Corp., will display flight path of missiles and other test vehicles on a terrain map, enabling tracking range operators to maintain constant surveillance during a test. Also, the information will help in recovering a test vehicle by pinpointing its landing place.

The computer accepts range, azimuth, and elevation data from a radar system, inserts parallax correction, and converts the data from polar to cartesian form for presentation on a rectangular coordinate plotting board. It automatically compensates for the earth's curvature in computing altitude of the tracked vehicle.

A built-in system allows the operator to check the computer's accuracy at the push of a button. A monitor and control panel permits visual check on values of all computed quantities and all internal power supply voltages.

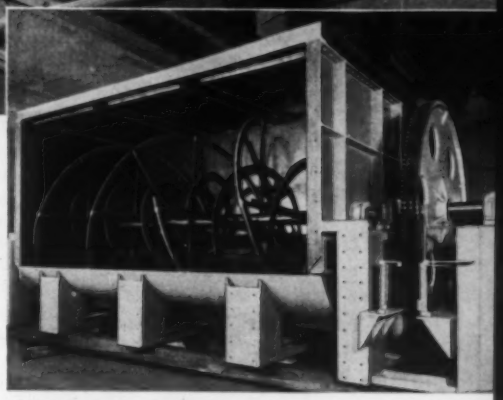
WORLD'S LARGEST BLENDER

Mixes 30 tons of Dextrin at once!

The J. H. Day Company personnel shown with Twin Jumbo Blender. It is 17 feet wide, 18 feet long— has twin spiral agitators 9 feet in diameter.

Mixing a carload of dextrin in one batch is a mammoth job. It requires big power correctly applied. For the final agitator drive, J. H. Day engineers selected Diamond Roller Chains. Their high uniform quality is assurance of maximum efficiency and years of maintenance-free performance.

Whatever your drive problem is, fractional or several thousands of horsepower, high speed or low, Diamond Roller Chain will serve you efficiently at low cost. Diamond Engineers are available to give you valuable assistance. Call on them now.



Half tank cross-section shows one 9 foot agitator and huge sprocket. *Diamond* triple strand 2" pitch Roller Chain drives agitator at 10 R.P.M.

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DIAMOND ROLLER CHAINS

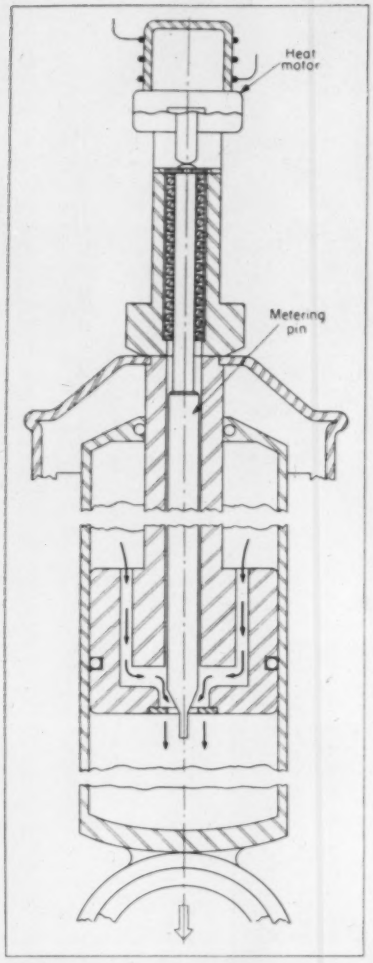
Driver Controls Rideability With New Automotive Shocks

CLEVELAND—New automotive shock absorbers developed by the Gabriel Co. make riding quality of the family car variable at the turn of a dial. Electromechanical in operation, the new shocks can be set to compensate for variety of specific road, speed, or load conditions.

Called Selectric Ride Control, the system incorporates hydraulic shock absorbers with small heat motors. Movement of the heat-motor diaphragm, in proportion to the current passing through the motor, causes a metering pin in the shock absorber to change valving and give a proportional change in shock-absorber resistance.

Two rheostats mounted on the dashboard show a range of settings from "soft" to "firm." Soft setting approximates the original riding quality of the car—desirable at low speeds or on choppy road surfaces. Firm setting is used when handling and manueverability of the car are of prime importance. This setting is also used to compensate for heavier loads and for high-speed turnpike driving, or driving in hilly areas where a good feel of the road is desirable. A time lapse of about 3 min is required for the system to respond to a complete change of setting from soft to firm. With front and rear shocks both at firm position, the system draws about 4 amp. With the ignition key off, or with the dial at soft position, no current is used.

According to Gabriel officials, the new Selectric system is the first to operate electromechanically. Other adjustable shock absorbers, including a variety of European makes, are entirely mechanical. Linkages required in a mechanical system often complicate the installation of this type of shock absorber in any car other than the model for which it was designed. The Selectric system was designed with the replacement market in mind, and is also being tested by several auto makers as possible original equipment.



Electro-mechanical automotive shock absorber, shown in this simplified schematic, has a heat motor at top containing heating coils, thermostat, and a special powdered-copper and wax mixture. Heat causes the mixture to expand against a diaphragm, forcing the spring-mounted metering pin downward to restrict flow of hydraulic fluid. Dual rheostats mounted on the dash control current flow to the heat motor, enabling the driver to vary hydraulic tension in front and rear shocks. Changes in ambient temperature are automatically compensated for by corresponding changes in density of the heat-motor mixture and viscosity of the shock-absorber fluid.

Explosive progress in the use of digital computers has been reported, and forecast, by GE spokesmen. The world has 150 large-size installations; 1000 medium-size; as many more planned. GE men say engineers are just beginning to learn to use them.

Topics

When a chicken crosses the road now it may be to check the egg-vending machine. Several hundred refrigerated, coin - operated dispensers are in use along highways, in gasoline stations, and near factories. Assuming the farmer receives 20 cents extra for each dozen by this direct-sale method, the machine will have paid for itself after dispensing about 8500 dozen eggs.

• • •

Skin diving without swimming is done by a Victoria, B. C., man who has built a 1 x 4-ft torpedo-like submarine for this purpose. Powered by a rewired generator from an old car, run off a 12-volt car battery, the sub carries the rider at a speed between 1 and 2 knots. It can dive, climb, roll, and loop the loop.

• • •

Where there's smoke there's not necessarily a smoker—a recently patented invention looks, burns, and smells like an ordinary cigarette but can't be smoked. It is for "social smokers" or those who need something to do with their hands. At the end of the cigarette where the filter would be is a plug. The tobacco is treated to burn by itself.

• • •

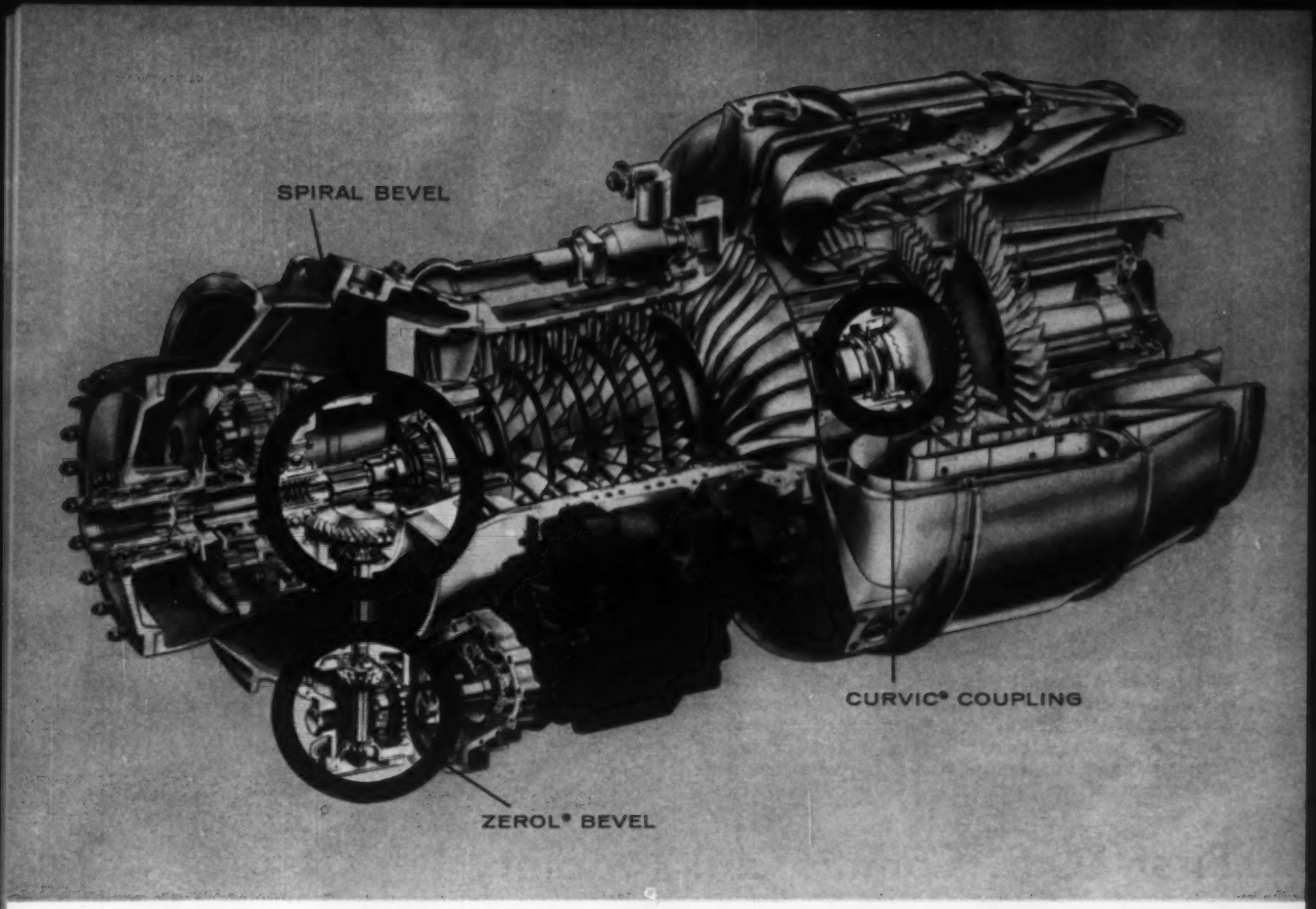
Five-billionths of a second exposure time is possible with a new camera shutter developed for the Army. It is a hermetically sealed, chemical-type shutter and is triggered electronically.

• • •

First successful surface measurements of gravity in the open sea have been made, using a new sea gravimeter, which makes possible the taking of gravity measurements simply and expeditiously any place on the ocean surfaces. The instrument was mounted on a gyro-stabilized platform aboard the *U.S.S. Compass Island.* Previously gravity values for ocean areas had to be measured in submarines at quiet depths.

• • •

Swing low, swift chariot: A recently patented invention lowers an automobile's body as speed increases, thereby increasing stability. Pumps, scheduled to the car's speed, force hydraulic fluid or compressed air into cylinders to change height of the body above the road. Clearance can be increased at high speeds if necessary.



How to get *engineering assistance* on gears and couplings like these

Gleason engineers are always ready to help you work out any problems involving bevel gears and couplings.

Such assistance came to the makers of this turbine in four different areas:

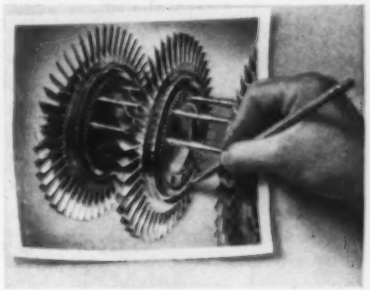
First, they naturally wanted components which met the designated theoretical requirements of the turbine. Our engineers helped determine the types and sizes of the gears and Curvic® coupling as well as such details as axial thrust and radial load.

Second, they wanted compactness. The angular drives made possible by the spiral bevel and Zerol® bevel systems helped materially to fit the drive into the limitations set by the turbine's over-all dimensions.

Third, they wanted low costs. The machines and methods developed by Gleason engineers assure the lowest possible costs for both gears and couplings whether made in small or large quantities. The Curvic coupling design inherently cuts coupling costs; see picture at right.

Fourth, the makers wanted extreme reliability. The success of the gears and couplings in this respect is witnessed by the fact that this turbine is used by six major aircraft companies and has recorded more hours of flying time than any other turbine in its power class.

If you would like to discuss your bevel gear or coupling application with a Gleason representative, please contact us.



With Curvic couplings complex machine parts can be made in several small units, reducing machining time, simplifying final assembly, and cutting over-all manufacturing costs.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Circle 408 on Page 19

The Lockheed Electra, America's first propjet airliner, is designed especially for commuter-type air travel on distances of 500 miles or less—travel that comprises nearly 87 per cent of the nation's scheduled flights. The new plane can utilize existing airports that serve 90 per cent of the nation's airline passengers. With a cruising speed in excess of 400 mph, Electra will also be the fastest propjet in commercial service. It will carry from 72 to 98 passengers depending on interior arrangement. Conceived in 1955, the big airliner completed its first test flight 56 days ahead of the original 30-month engineering-production schedule.

First U. S. Commercial Propjet Soon to Enter Airline Service

Electra will carry 72 to 98 passengers at 400-plus mph on short hauls, less than 500 miles. Turn-around will be 14 min.

BURBANK, CALIF.—In less than a year, airline passengers may fly in the first propjet airliner designed and built in this country. Lockheed Aircraft Corp. has successfully completed first test flights of its new Electra airliner and is scheduled to begin delivery next September on a backlog of 141 planes.

To fulfill its mission—fast, economical, short-trip passenger service—the new Electra is designed around four Allison propjet engines. Lockheed engineers explained that propjet power, as opposed to pure jet or piston engines, provides the advantages of short take off runs, low fuel consumption, relatively fast flying speed, and immediate power response at any altitude. Certain technical factors are responsible for these advantages. Frontal area of the propjet engine nacelle is half that of piston engines; the engine weight is half that of comparable reciprocating types; propellers assure the most efficient performance for takeoff and initial climb; and propjets furnish quiet performance both inside and outside of the aircraft, along with a marked reduction in vibration.

Each engine is rated at 3750 equivalent shp, which includes direct power on the propellor shaft plus thrust from the jet exhaust. Total power at takeoff is 15,000 hp. Four bladed, reversible-pitch propellors are 13½ ft in diameter; blades are 18 in. in width.

The Electra's 104-ft fuselage has an inside diameter of nearly 11 ft —wider than any modern transport flying today. With "super-luxury" arrangement it will carry 66 passengers in regular seating plus 6 in the lounge. In first-class arrangement it will seat 98. Other specifications include wingspan, 99 ft; height over tail, 32 ft. Weight empty is 56,000 lb; gross takeoff weight, 113,000 lb.

New, built-in servicing facilities are partially responsible for the fast commuter service expected from the Electra. Single-point pressure fueling, large integrally lighted service centers, carry-on luggage racks, and integral stairs, will reduce on-the-ground time between flights to a scheduled 14 min.

Full-Color Prints Made In One-Minute Cameras

CAMBRIDGE, MASS.—Laboratory research on color films has advanced to the point where full-color prints are being made directly in Polaroid Land cameras. Dr. Land, company president, stated that preparing for production of the new color rolls is a major undertaking involving several stages. These stages may take several years, he said, and he could not now predict when the new color rolls will be ready for marketing.

The present plan is to design the new films to fit cameras in the current line, so that users can take pictures in full color as they now take them in black and white. Like the present black-and-white rolls, the color rolls will consist

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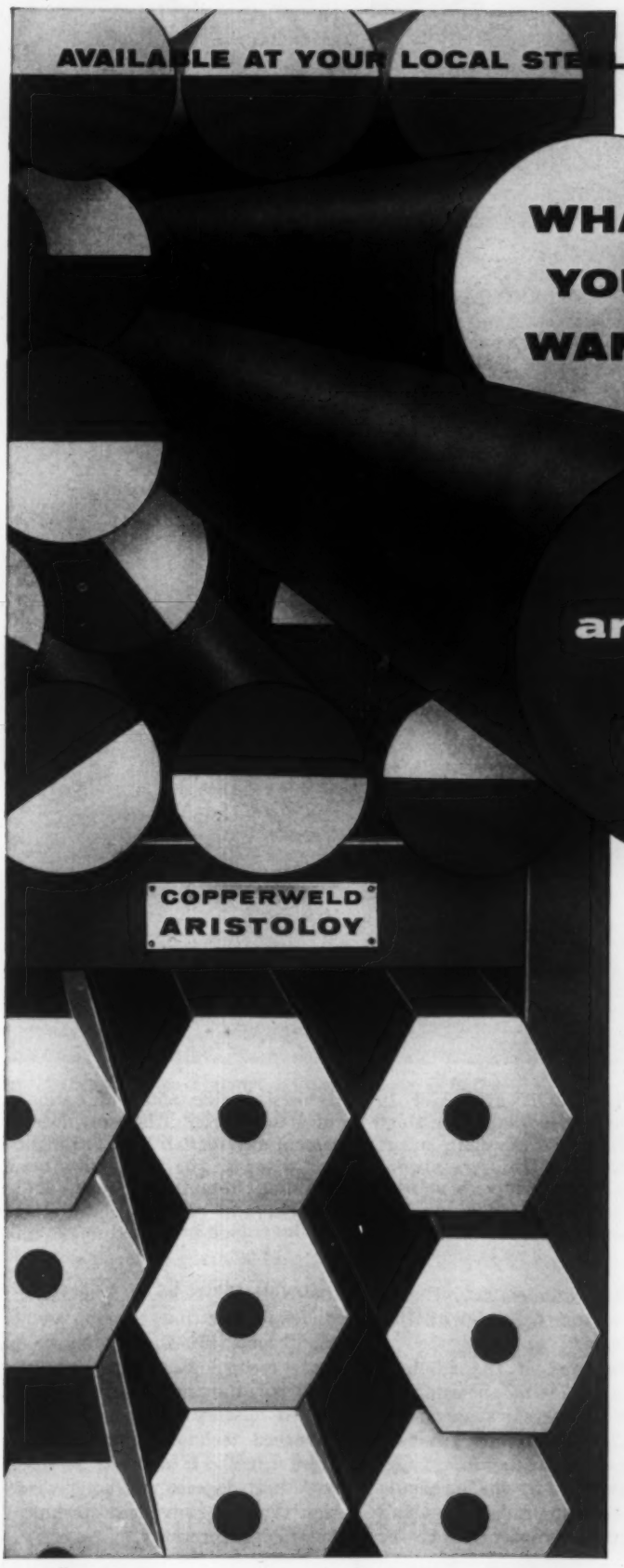
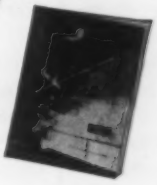


Today's steel warehouses, scattered across the country, provide fast truck delivery of Aristoloy bars, hexes and rounds, in a wide range of A.I.S.I. grades and sizes. A telephone call to one of these modern steel service centers will put you in touch with an immediate source for most of your steel needs. Your local steel warehouseman can ease your inventory burden and the expense and trouble of stocking these items. He is also well equipped by training and experience to offer technical advice . . . to assist you in selecting the best Aristoloy to do your particular job.



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ARISTOLOY STEELS

of two components, a roll of negative and a roll of self-processing positive paper.

Dr. Land further announced that a contract was signed recently with Eastman Kodak Co., which authorizes Kodak to develop methods for the manufacture of materials for the new color process and to use the process in certain applications not involving Land cameras.

Engineering Society Hits Ike's Scholarship Plan

Fears Additional Burden For Cash-Short Colleges

WASHINGTON—President Eisenhower's proposal for 10,000 undergraduate scholarships annually for the next four years will create added burdens for colleges already struggling financially, and will place the wrong emphasis on the engineering manpower problem, a spokesman for the National Society of Professional Engineers has stated.

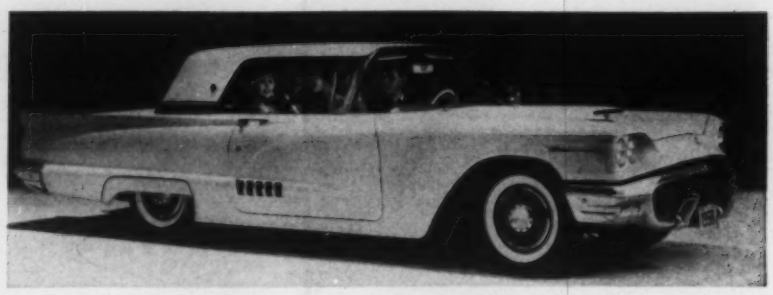
Dr. Clark A. Dunn, vice president of NSPE and director of the Engineering Experimental Station at Oklahoma State University, said the administration plan "will complicate and aggravate an already serious situation."

He emphasized that "tuition does not cover the cost of collegiate education," and the difference must be made up from private or public assistance. "The plan does not provide any aid for the colleges to meet the added costs which will result," he said.

Dr. Dunn pointed out that "engineering enrollments are at an all-time high and are continuing to increase. The educational institutions are already handicapped severely in giving adequate attention to capable students. A new influx of enrollments will strain the faculty and facilities of the institutions beyond the breaking point unless some substantial assistance is provided.

"The colleges are now in a serious plight with regard to faculty salaries and are losing faculty staff to industry and others through substantially higher salary offers. The administration plan does not appear to deal with this vital problem."

Some features of the administration plan are sound, he said, and should be supported, such as the provision of additional graduate fellowships, including some supporting funds for the graduate schools. He also praised the plan's increase in the appropriations for the National Science Foundation. He explained that those pressing for federal aid should remember that technological developments such as the earth satellite and guided missiles depend on highly-advanced technology, and that a mere increase in numbers of those with first degrees will not provide the type of advanced technical knowledge necessary.



FOUR-PASSENGER THUNDERBIRD for 1958 is 2 ft longer and 4 in. wider than last year's two seater. Ease of entry for rear seat riders is obtained by fold-flat front seats and exceptionally wide—48.7 in.—door openings. Front and rear headroom is within a fraction of other luxury cars, although the Thunderbird is 4 in. lower than the average U. S. luxury car. Unitized body-frame construction is again featured. Performance is maintained with a 300-hp engine featuring a machined combustion chamber.

Thunderbird Engine Specifications

Bore & stroke (in.)	4.00 x 3.5
Displ. (cu in.)	352
Comp. Ratio	10.2 to 1
Bhp. max	300 @ 4600
Torque, max (lb-ft)	395 @ 2800

Size and Weight

Wheelbase (in.)	113
Length (in.)	205.4
Width (in.)	77
Height (in.)	52.5
Weight (lb)	3708

Corvette Engine Specifications*

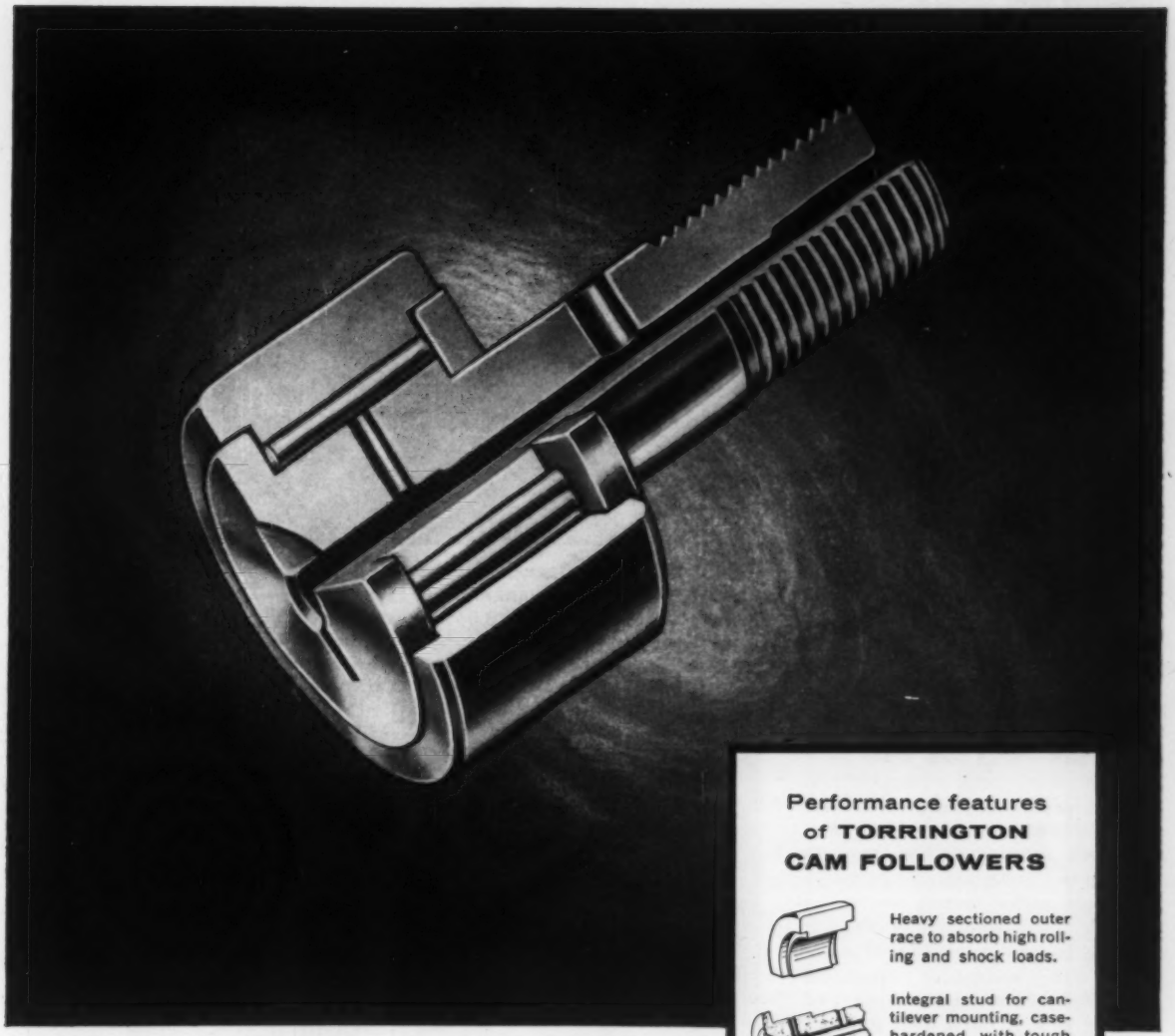
Bore & stroke (in.)	3.87 x 3
Displ. (cu in.)	283
Comp ratio	9.5 to 1
Bhp. max	230 @ 4800
Torque, max (lb-ft)	300 @ 3000

*Standard engine with 4-barrel carburetor.

Size and Weight

Wheelbase (in.)	102
Length (in.)	177.2
Width (in.)	72.8
Height (in.)	51.1
Weight (lb)	2912

CHEVROLET CORVETTE for 1958 features a wide range of optional items, including fuel injection, single or dual four-barrel carburetors, heavy-duty clutch, special camshaft, and twin-traction differential. Dual headlights and a redesigned grille are major exterior changes. The cockpit has been extensively revamped, with a divider extending from floor tunnel to instrument panel as an additional site for instrument mounting. With fuel injection and special camshaft, standard 230-hp engine is boosted to 290 hp.



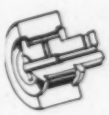
Performance features of TORRINGTON CAM FOLLOWERS

Heavy sectioned outer race to absorb high rolling and shock loads.

Integral stud for cantilever mounting, case-hardened, with tough core for high strength to withstand shock loads.

Easily relubricated at either end or through cross hole in stud. Ends accommodate standard drive grease fittings or plug seals.

Full complement of small diameter rollers for maximum radial capacity and efficient anti-friction performance.



Races precision ground for even load distribution and uniform low end play.

Built to "FOLLOW THROUGH" under high shock loads

Every feature of the Torrington Cam Follower is designed to insure efficient performance and long service life under heavy rolling and shock loads in cam or track follower service.

Precision made throughout, Torrington Cam Followers are available in sizes from ½" to 2¼" OD. Special surface finishes such as chrome and cadmium plate or oxide black can be provided.

Our engineering staff will be glad to work with you in applying these reliable units to your cam-controlled or track-type equipment. You can depend on Torrington Cam Followers to "follow through" on the job because every element is designed for ultimate capacity. *The Torrington Company,* Torrington, Conn.—and South Bend 21, Ind.

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District Offices and Distributors in Principal Cities of United States and Canada

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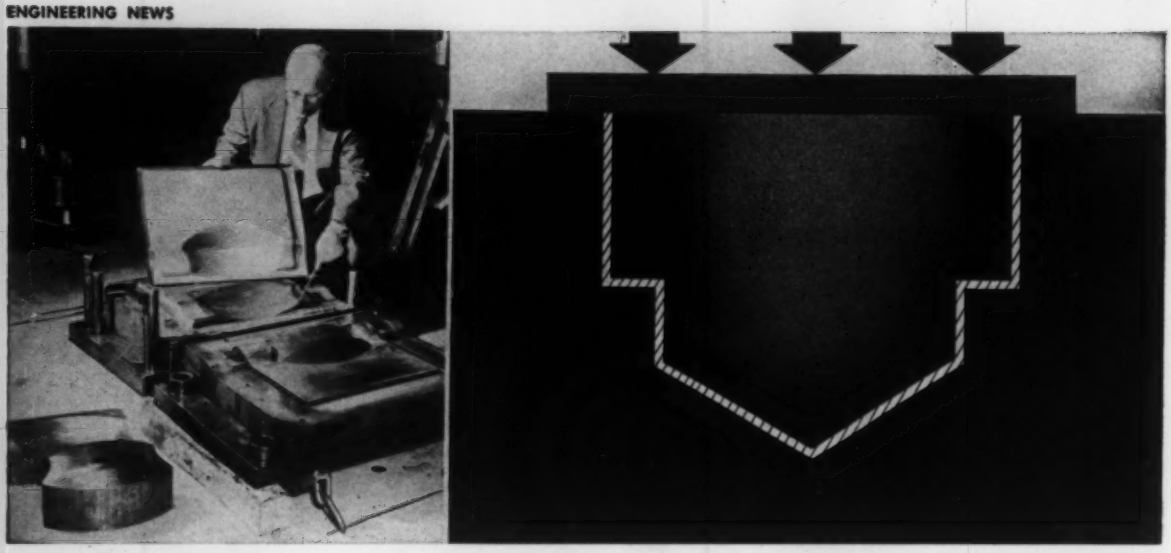


To produce bottom panels for refrigerators, Epoxy-Alloy die inserts form a cavity in the stamping. More than 65,000 parts have been produced on these dies using 0.035-in. steel sheet. The new process is claimed to show many improvements over unfilled and powder-filled cast, heat-resistant epoxy systems. Flexural modulus of elasticity, impact strength, and thermal conductivity are said to have been increased several times.

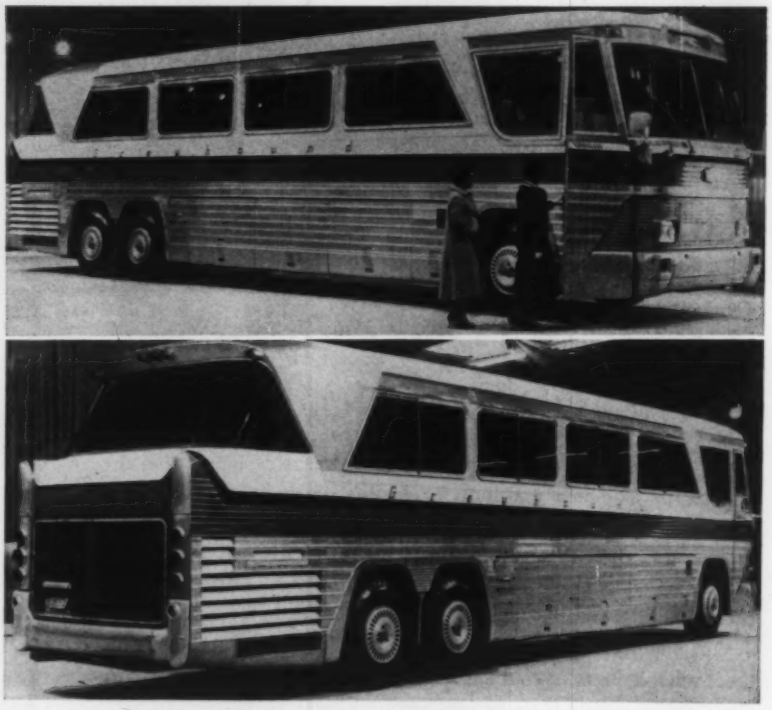
Metal-Plastic Dies Give Medium Production Runs

Retain Plastic Economies, Offer Greater Strength

NEW YORK—With dies made of a new plastic-metal composition, medium production runs have been achieved with plastic tooling. The improved tooling method permits runs up to 150,000 stampings where low-gage, softer metals are to be formed. This technique is also applicable to prototype and development dies, secondary operation dies, Hydroform and rubber pad forming dies, stretch dies, and fixtures.

The new process, which makes use of epoxy-resin material reinforced with metal or glass fibers and called Epoxy-Alloy, was announced recently by Bakelite Co., div. of Union Carbide Corp. According to the company, reduced tooling time and cost economies associated with plastic tooling are carried over to this new technique. Improvements claimed, with respect to conventional plastic tooling, include mass casting of the tools and dies, substantially increased thermal conductivity, and greater modulus and impact strength.

Use of the Epoxy-Alloy system resulted from a three-year development program carried out by the company in co-operation with tool and die fabricators. These investigations have shown that draw dies of this material can be used for



PASSENGERS RIDE HIGH in newly designed cross-country bus. Design aim was greater comfort for the passengers. The most unusual feature is the full-length observation deck which allows passengers and driver to ride high up in the panoramic dome. The lower level provides baggage space. High seating plan allows roomier interior without increase in over-all size of the bus. Built by Mack for the Greyhound Corp., the bus features a huge wrap-around windshield in the rear as well as the front, and special sky watch windows in the ceiling along the full length of the vehicle. Interior features include a large rear lounge, lavatory, folding utility tables.

the following runs:

1. 50,000 to 150,000 or more stampings of the thinner, more easily formed metals.
2. 10,000 to 50,000 stampings in which metal-plastic contoured punches and pads are used with metal inserts, draw rings, and blank holders.
3. 1000 to 10,000 stampings without the use of metal rings or inserts.
4. Prototype or development runs encountering deep draws of heavy metal or large compound-contour stampings up to ¼ in. thick steel.

Measure Rocket Thrust Available from Plasma Jet

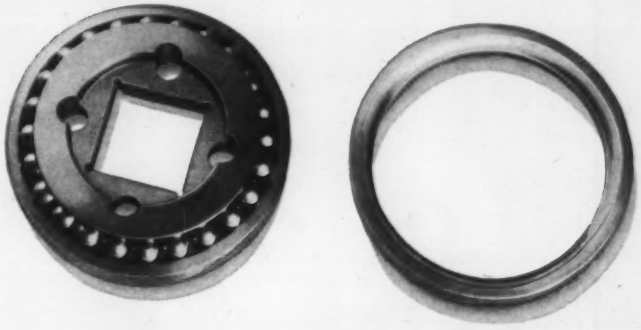
Specific Impulse of 600 Sec Obtained in Experimental Study

SANTA ANA, CALIF.—First known measurements of propulsion with ionized gases (plasma) show specific impulses as high as 600 sec with ion jet temperatures in excess of 17,500 F. At the Giannini Research Laboratory, an experimental study of the thrust characteristics of continuous running plasma sources has resulted in quantitative data.

Dr. Vernon H. Blackman, in a paper given before the Advanced Propulsion Symposium in Los Angeles pointed out that values measured are twice those of the most advanced chemical rockets and that values above 1000 sec can be readily produced by increasing the input energy. Argon and helium were used as the working fluid. Dr. Blackman predicted that impulses even higher will be obtained by using hydrogen as the working fluid.

The measurements indicated a degree of ionization between about 0.5 and 15 per cent, depending on the time available for the gas to reach thermodynamic equilibrium. The power input in the gas was measured directly. The fraction of this power in random motion of the particles (temperature), directed motion (thrust), and ionization was determined as a function of gas mass flow rate and chamber pressure.

Square-Hole Ball Bearing Simplifies Antenna Design



This radar bearing, 1.500" OD, carries 3000 lb. thrust while turning through 180° at 90 oscillations per minute. The split outer race permits larger ball complement and increased load capacity.

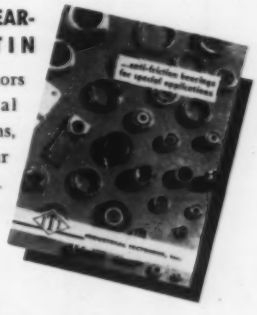
In planning the mechanical design of a radar antenna, the designer found that by using a ball bearing with a square hole, he could avoid limitations imposed by standard bearings. To bring this dream to reality, he had Industrial Tectonics design and produce the special bearing shown above. This has resulted in (1) a simpler and less costly design of the assembly that the bearing carries, and (2) a stronger and more rigid support.

In this and many other ways, the availability of ITI special bearings permits new freedom of design, and new economy. Remember —

IF YOU need anti-friction bearings of *special shape, size, heat resistance, corrosion resistance, low torque, ultra precision, non-magnetic properties, or other unusual characteristics,* we can supply them — designed and built to your specific requirements. We invite your inquiries.

FREE 20-PAGE BEARINGS BULLETIN

tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-2.*



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MANUFACTURERS OF PRECISION BALLS AND BEARINGS

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WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

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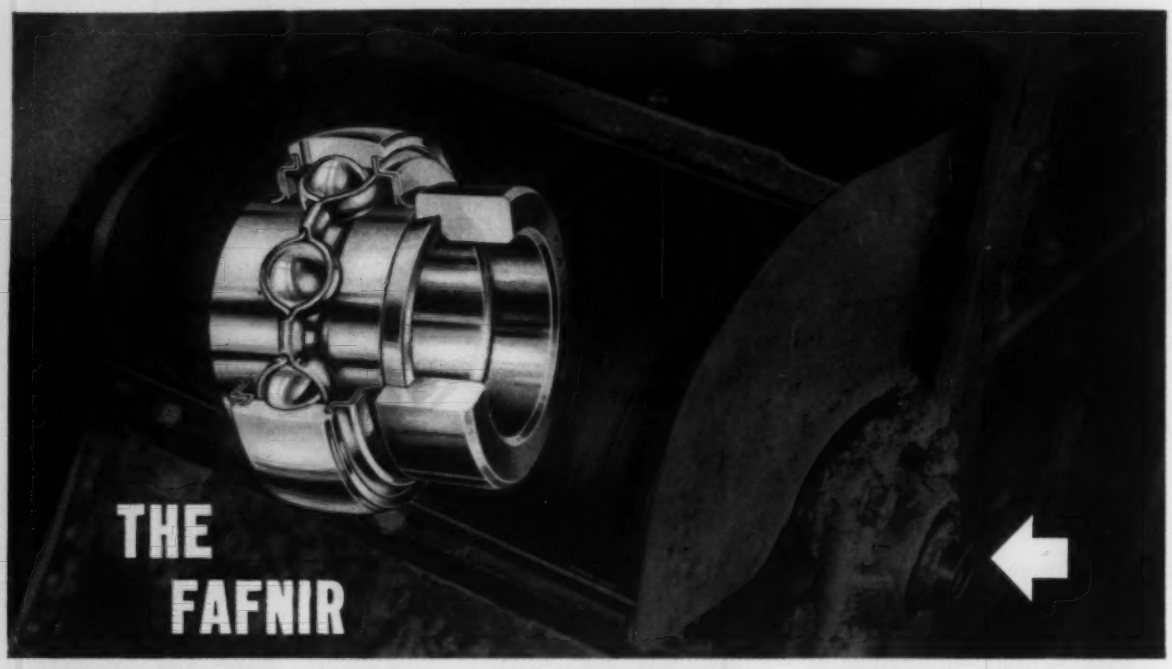
TWO GREAT BEARING DEVELOPMENTS ROLLED INTO ONE!



PLYA-SEAL WIDE INNER RING BALL BEARING

Designed expressly for slow speed applications and wet or dirty operating conditions

New Fafnir Plya-Seal Wide Inner Ring Ball Bearings are a combination of two outstanding bearing developments. The most effective seal ever devised for retention of grease and protection against contamination, plus the famous Fafnir self-locking collar, for cost-cutting, twist-of-the-wrist bearing installation. This combination of features offers you several advantages . . .

Best protection yet against dirt, dust, steam, water, lint, other contaminants on slow to moderate speed applications. Contact-type, Plya-Seals seal out abrasive or corrosive material, seal in factory prepacked lubricant.

Less Maintenance — In many applications, non-relubricatable bearings may be used. They require virtually no maintenance time or expense. In other applications, where bearings receive hard or constant use, relubricatable types are available. They require only occasional greasing, even under severe conditions.

Longer Service life — Plya-Seals protect against premature bearing wear or failure. Contaminants cannot damage balls or races; sealed-in lubricant ensures against bearing "running dry".

Simplified Designing — Bearing housings may be designed without incorporating separate housing seals. Plya-Seals provide full protection; make possible simplified, less costly, more compact housings.

Power Transmission Units incorporating new Fafnir Plya-Seal Wide Inner Ring Bearing

RAK and RAS Type Pillow Blocks

RCJ Type Flange Cartridges

Fafnir Flangettes

Write for bulletin containing complete specifications on Fafnir Plya-Seal Wide Inner Ring Ball Bearings and Power Transmission Units. The Fafnir Bearing Company, New Britain, Conn.

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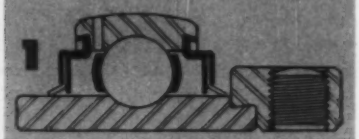
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA



PLYA-SEALS

As incorporated in the Fafnir Plya-Seal Wide Inner Ring Ball Bearing, the Fafnir Plya-Seal consists of a synthetic rubber-impregnated fabric sealing washer sandwiched between dished steel plates. Seal flares out, maintaining constant contact with ground outside diameter of inner ring. Years of service have proven Plya-Seals the most effective seal ever developed for ball bearings.

SELF-LOCKING COLLAR

Originated by Fafnir, this famous development has cut costs and simplified assembly throughout industry. Bearings slip onto shaft; are locked securely with simple twist of self-locking collar. No need for lock nuts, shoulders, sleeves, washers, or adapters. Positive binding action increases with use.

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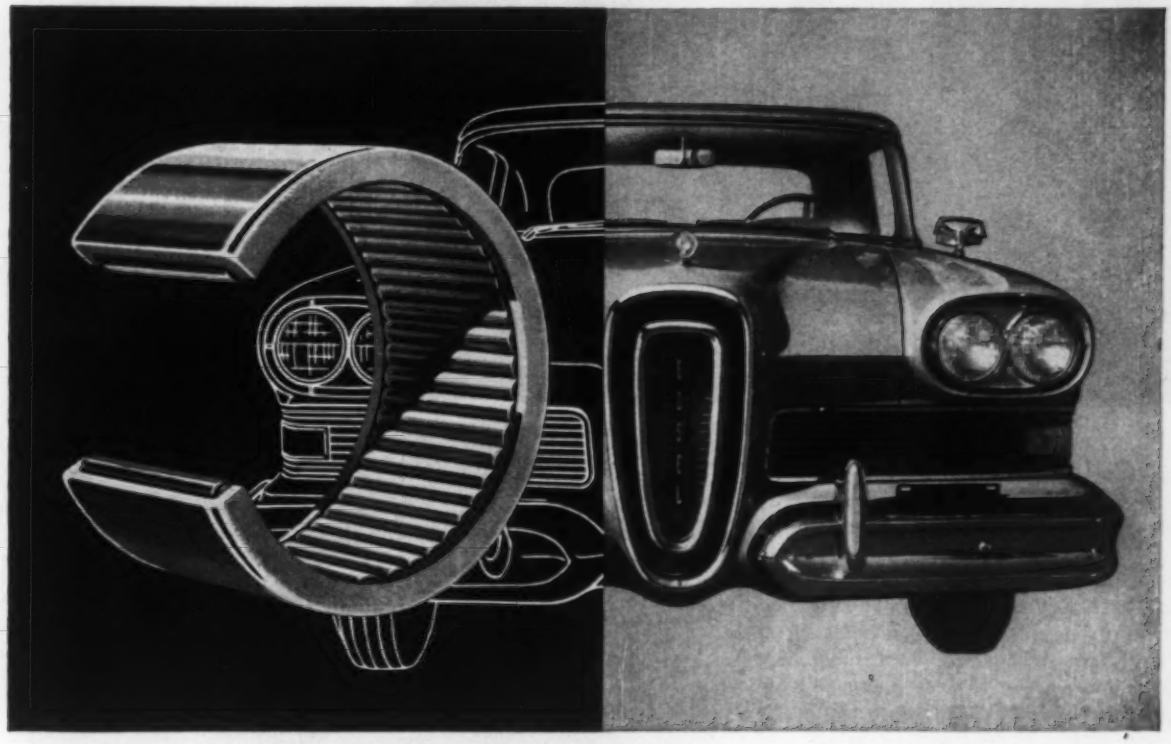
America's newest thin-shell needle bearing



. . . now in America's newest automobile

Developed with the cooperation of Ford Motor Co., these KAYDON bearings are used in the automatic transmissions of Edsel as well as Ford and Mercury

The 1958 Edsel, America's newest automobile, backed by more than 1,250,000 road-test miles, employs in its transmission, America's newest thin-shell needle bearings, introduced by Kaydon of Muskegon. Why?

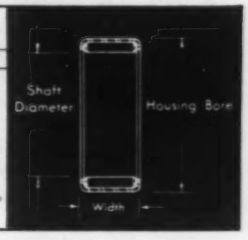
Proven in Ford-O-Matic and Merc-O-Matic transmissions, these Kaydon thin-shell needle bearings deliver 46% more bearing capacity.

Greater effective length of spherical end rollers does it. Important too, simplified construction, pre-packed lubrication, saves money . . . and saves valuable time on the assembly line too! See table below for standard Kaydon thin-shell needle bearing sizes.

AVAILABLE FROM STOCK IN 5 STANDARD SIZES:

SHAFT DIAMETER	HOUSING BORE	WIDTH
1.0605"	1.3130"	.500"
1.1250"	1.3755"	.750"
1.1250"	1.3755"	1.000"
1.1875"	1.5005"	.625"
1.3750"	1.6875"	.625"

For other sizes and complete specifications, write or call KAYDON of Muskegon today.



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All types of ball and roller bearings — 4" inside diameter bore to 160" outside diameter . . .
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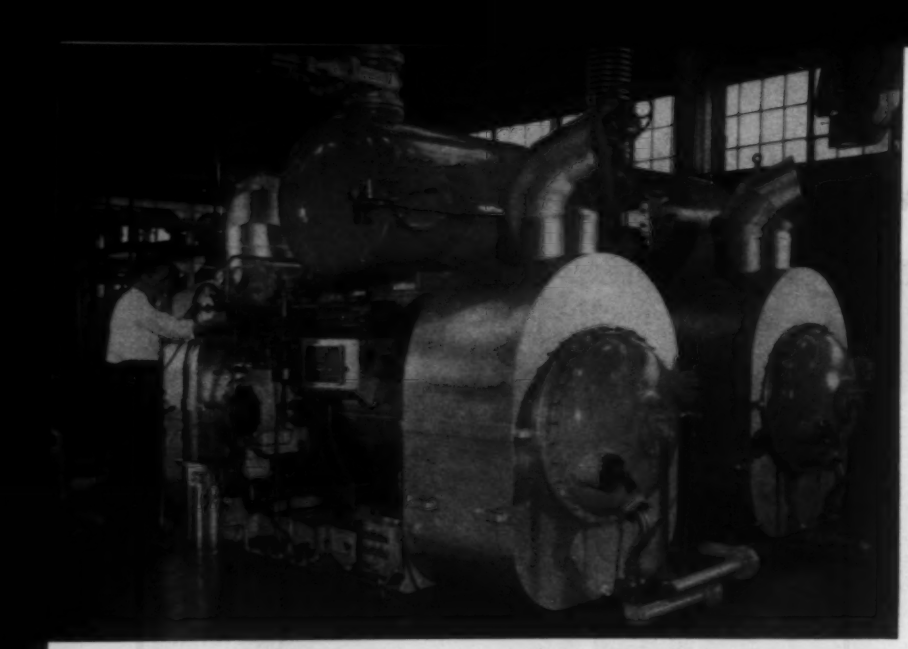
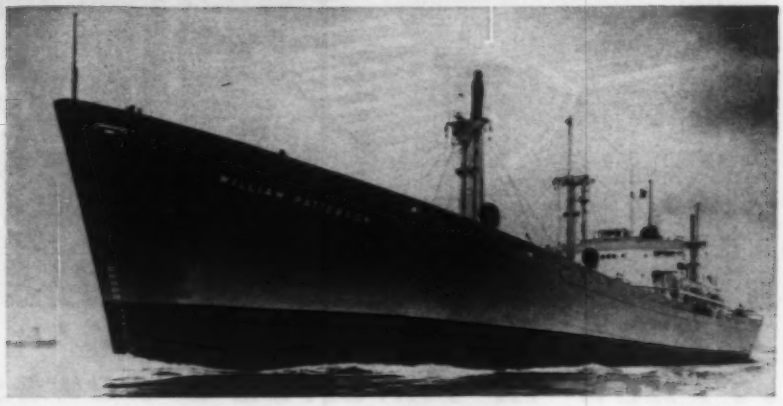


The 6000-hp free-piston turbine installation in the G.T.S. *William Patterson* is a first in several respects. It is the first marine installation of its kind in this country, and the largest marine installation of its type in the world. Six GM-14 gasifiers, designed and built by Cleveland Diesel Engine Div., General Motors Corp., are connected to a common header and supply gas to two turbines. Two of the units are shown here on a test stand. Each gasifier delivers 1233 gas hp and operates at a thermal efficiency of 41 per cent. Turbine efficiency is 85 per cent, giving the overall system an efficiency comparable to a diesel installation. A unique advantage in the free-piston system is the ability to cut out one of the engines for servicing without significant loss in speed or power.



Free-Piston Engine: . . . . . POWERPLANT WITH A

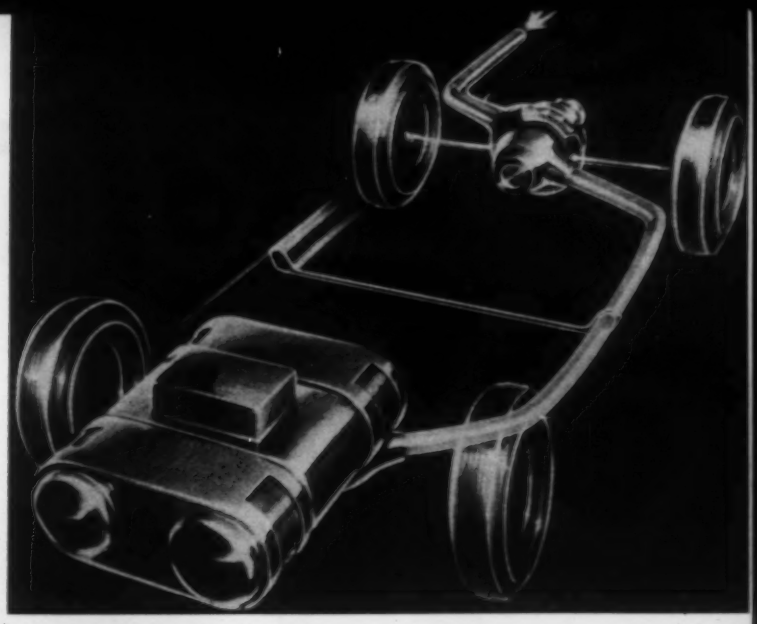
A 30-year-old engine is proving to be a major contender in many power applications formerly reserved for diesel and gasoline engines. Free-piston gasifiers, used in Europe for many years as simple, dependable air compressors, already compete favorably with diesel power and offer a challenge to the standard of the automotive industry, the gasoline engine.

In its new role as prime mover, the free-piston engine is combined with a turbine and comes up with remarkable possibilities in efficiency, simplicity and power-to-weight ratio. Furthermore, it shows some definite advantages over other power sources: it can digest a wide range of fuel and is extremely flexible in the matter of space arrangement.

U. S. firms are experimenting with free-piston engines; several have designed power plants for specific applications and installed them in prototype models. Ford's experimental Typhoon tractor and General Motors' XP-500 automobile are notable examples. A marine propulsion unit — the first commercial application of its type in the U. S.—is currently being installed in the converted Liberty Ship *G.T.S.* (Gas Turbine Ship) *William Patterson*.

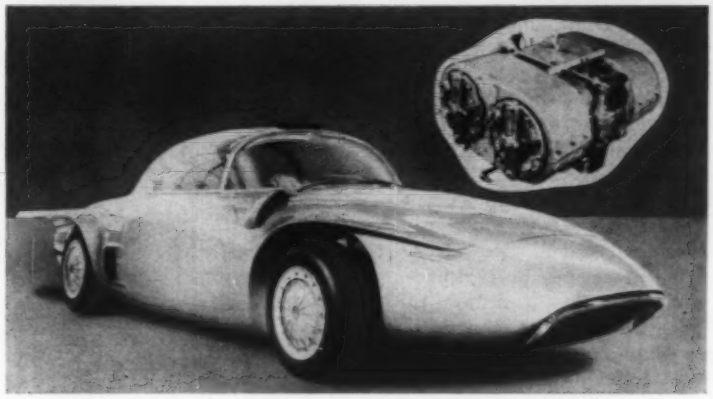
At this stage of development, research men are quick to emphasize the experimental nature of their work and few make predictions. According to A. F. Underwood and Gregory Flynn Jr., engineers with General Motors' research staff, the free-piston engine has many outstanding features:

Fuel Insensitivity: The free-piston engine will run on a range of fuels varying from 100-octane gasoline to crude oil. If none of these are available, whale oil, cotton seed oil, or peanut oil will suffice. The only noticeable effect on engine performance seems to be power output, which varies directly as the heat content of the fuel being used. Because of the high com-



General Motor's experimental XP-500 uses the first "siamesed" gasifier ever built. The compact unit is just 40 in. long, 34 in. wide, 18 in. high. It consists of two complete cylinder assemblies in a single package, using a common air inlet and common exhaust. Bore of the power cylinders is 4 in., diameter of the compressor piston, 11 in.; stroke is about 5 in. Maximum cyclic speed is 2400 strokes per min. Rated at 250 gas hp, the engine compares in performance to present automobile engines of about 300 hp.

Phantom view of the powerplant in the XP-500 illustrates two unique advantages of the free-piston-gasifier in automotive applications. Desirable weight distribution is obtained by having engine in front and transmission in rear; no tunnel is required in the body for a transmission or propeller shaft. In place of the usual drive shaft a 3½-in. insulated pipe runs through the left frame of the car carrying exhaust gas to a five-stage, axial-flow turbine. Power output from the turbine is through a gear box having a reduction ratio of about 7 to 1.



FUTURE

bustion temperature, exhaust remains absolutely clean.

High Efficiency: Overall efficiency of the engine is the product of the gasifier and turbine efficiencies. GM's engine operates at a compression ratio of between 30 and 50 to 1. Gas is generated at an efficiency of 40 to 45 per cent at full load; turbine efficiency is 80 per cent. This gives an overall thermal efficiency of about 80 per cent, making the engine competitive with high-compression diesel and gasoline engines.

Low Turbine Temperature: An outstanding advantage of the free-piston cycle is the very low temperature of the exhaust gas entering the power turbine. Temperature ranges from 450 to 900 F, much lower than temperatures encountered in the combustion turbine cycle, and lower than the exhaust temperature of an automobile engine.

Power turbines can thus be manufactured from noncritical alloys, readily available at moderate cost. This low-temperature feature also gives the designer an independence in locating the gasifier and turbine. The gasifier can be placed where it is most convenient for weight or space consideration; the turbine can be located at the point of power application.

Smooth Operation: Free-piston engines are inherently balanced and require only that all oscillating or reciprocating parts be exactly the same weight. This means practically no vibration plus the fact that motor supports can be located without regard to torsional movement, since there is none.

An example of this inherent balance is demonstrated by a 1250-hp unit which GM has been running for three years. The gasifier is mounted several feet above the floor on supporting I-beams. Each piston weighs 1145 lb and reciprocates at approximately 600 cycles per minute. Although the engine frame is not bolted to the floor, there has never been the slightest movement of the unit.

Fast Throttle Response: One of the most attractive features of the free-piston engine for vehicle use is the rapidity with which it can increase its gas, or power output. There is no question of accelerating moving parts over a period of time. Pistons in the gasifier must stop and start at the end of each stroke, making gas production entirely dependent upon speed controls. These controls can be made to operate quickly, resulting in almost immediate power response.

As an additional attraction, power and acceleration of the engine can be greatly enhanced by connecting a simple afterburner between the engine and turbine. Due to the low exhaust temperature of the gasifier, an increase of 250 F can be used continuously without damaging turbine blades or other components. Higher temperatures can be used for shorter periods of time. Since power increase is ap-

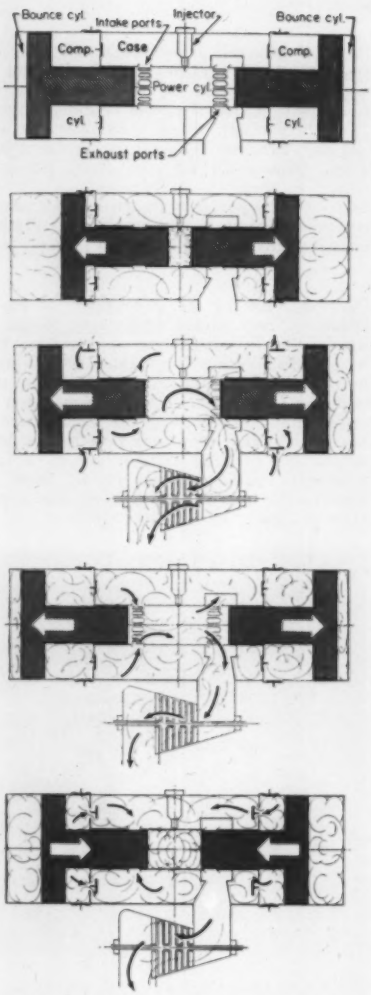
proximately proportional to the absolute temperature of the gas entering the turbine, use of the afterburner provides an almost instantaneous surge of additional power and acceleration.

Deceleration is also rapid. The gasifier slows down its production of gas directly as fuel flow is reduced. In fact, when fuel is cut off, the engine stops on the next piston stroke. Gas in the pipe between gasifier and turbine must be expended before there is zero torque on the turbine, but this is easily accomplished through the use of bypass valves.

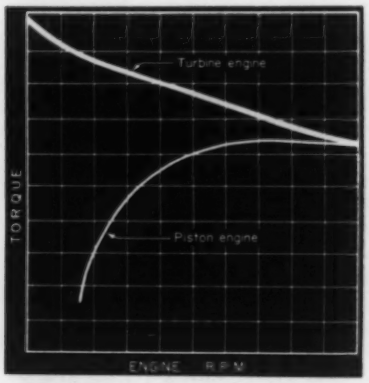
Simplicity and Serviceability: Maintenance of free-piston engines is expected to be a lesser problem than maintenance of other comparable engines. The free-piston engine has no crankcase, eliminating the problem of oil dilution, and it has no crankshaft, connecting rods, or mechanically actuated valves. Compressor inlet and outlet valves are of the reed type which do not contact hot exhaust gases and which are not required to seal at pressures greater than 60 psig. No high-tension electrical system is required. Lubrication requirements are not severe, since power is not transmitted mechanically through bearings. Similarly, service life of the engine is expected to be materially greater than that of other engines because of the complete absence of heavily loaded bearings. Engine assembly is easily accomplished, and accessibility to all parts can be made convenient for inspection and maintenance purposes.

A feature of the free-piston engine is the basic "building block" which it gives the engineer. A family of engines can be designed with practically the same components. Higher horsepower is developed by two or more identical engines feeding into a common header.

Futures: The free-piston engine appears to be well suited for vehicle use. With its potential fuel economy, flexibility in space arrangement, excellent performance characteristics, and simplified construction leading to economical production, it meets a number of basic automotive requirements. Its future is promising—and "promising" is as far as most automotive research men will commit themselves. But if improvements in performance and durability continue to keep pace with recent progress, the free-piston engine may soon be a real contender as an automobile powerplant.—C. E. WISE



The free-piston engine is basically a two-cycle diesel engine with a built-in air piston compressor for scavenging purposes. Illustration, above, shows operating sequence.



Performance of Ford's experimental Typhoon Tractor typifies some of the inherent advantages of gasifier-turbine operation in heavy-duty applications. Torque increases as speed is reduced. Thus, torque characteristics are significantly better suited for a tractor than torque characteristics of reciprocating engines in use today. Another advantage of the gasifier is its immediate response to power demands. When a governor or other sensing mechanism demands more power, the gasifier responds fully in one cycle. This feature is particularly important in a tractor operation, since load demands often come suddenly and the tractor has little inertia at low working speeds. Engine specifications include: bore, 3.75 in.; stroke, 4.2 in.; mechanical compression ratio, 15 to 1. Power-shift transmission is used with ten speeds forward, two speeds in reverse. Diameter of the power turbine is 6 in. Ratio of turbine revolutions to rear wheel revolutions, in first gear: 5600 to 1. The Typhoon is generally rated at 100 hp, although testing has been confined to a 50-hp output.

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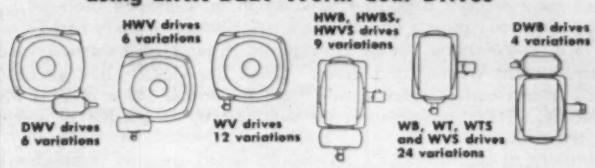

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Modular units, available in colors, form space-saving combinations. Future units may make complete meals automatically.

Straight-Line Style, More Conveniences, Are Features of

EFFICIENCY AND CONVENIENCE are achieved with modular, built-in appliances in this "Golden Dreams" kitchen by Westinghouse. Seven major appliances, all commercially available now, fit in an L-shaped area 14 by 20 ft with supplemental cabinets and counters. Appliances include two 17-in. waist-high ovens, conventional range, refrigerator-freezer, dishwasher, food waste disposer, clothes washer and dryer. Small appliances have an area of their own. A cart carries food to and from the table. One area is the housewife's office. Fresh condiments are supplied by a garden of living herbs above the sink.

VERTICAL FREEZERS gain in popularity over horizontal types. This is Frigidaire's 14.2 cu ft Imperial model styled to match the refrigerator of nearly the same volume. Three of its shelves are separately refrigerated. The fourth is removable to permit storage of bulky items.

UNIFORM COLD is assured in this Frigidaire 12.5 cu ft refrigerator by an air-circulating fan. Excess moisture from automatic defrosting drains out the bottom. The cubes are made at the lowest level. Slight manual force frees cubes when trays are inserted in an ejector.

Electrical

Kitchen Appliances for 1958

"NO SPACE TO WASTE" may well have been the watchword when appliance designers planned the 1958 models of domestic freezers, refrigerators, and ranges. For years their concern has been to use every cubic inch of interior volumes. Today, it's equally important that exteriors fill kitchen space efficiently.

Style: To satisfy this two-fold requirement, designers have originated a boxy, rectangular, functional style expressed in modular dimensions. Severe basic shape is relieved by tasteful trim, textured panels, and assortments of pastel colors. Simplified contours of both inside and outside surfaces make the units easy to clean.

Boxy styling started several years ago and has now extended to most appliance lines. Besides economy in the use of kitchen space, the straight lines enable savings in production. Westinghouse has demonstrated that plastic sheets, laminated with layers of insulation, can be folded together like cartons. Absence of expensive press operations permits quick model changes and more variety within model lines.

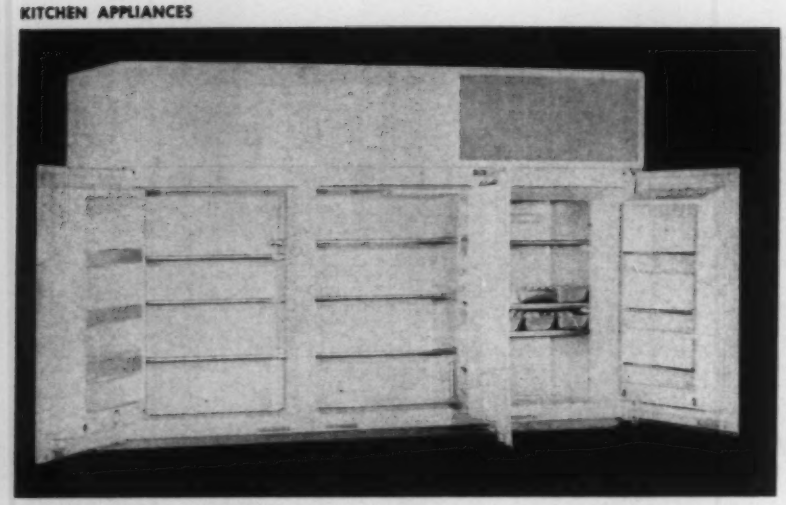
Where manufacturers market several kinds of appliances, style themes are uniform throughout. Appliances in groups then look like they "belong together." The Westinghouse Golden Dreams Kitchen is an example.

Materials: The trend for plastics to replace other materials is continued in 1958. In particular, the industry sees more reinforced plastics used this year. In 1957, appliances used 3 per cent of all reinforced plastics made.

Representative of the trend is General Electric which makes the substitutions from the inside out. Plastics line the interiors of cabinets before they're used outside.

Conveniences: More automatic help for the housewife and faster cooking are the purposes of a number of 1958 conveniences. Frigidaire ranges have an automatic electric meat tending device. A dial is set at the desired temperature and a sensing device is inserted in a roast. A buzzer signals when the meat is done.

Frigidaire ranges also have a

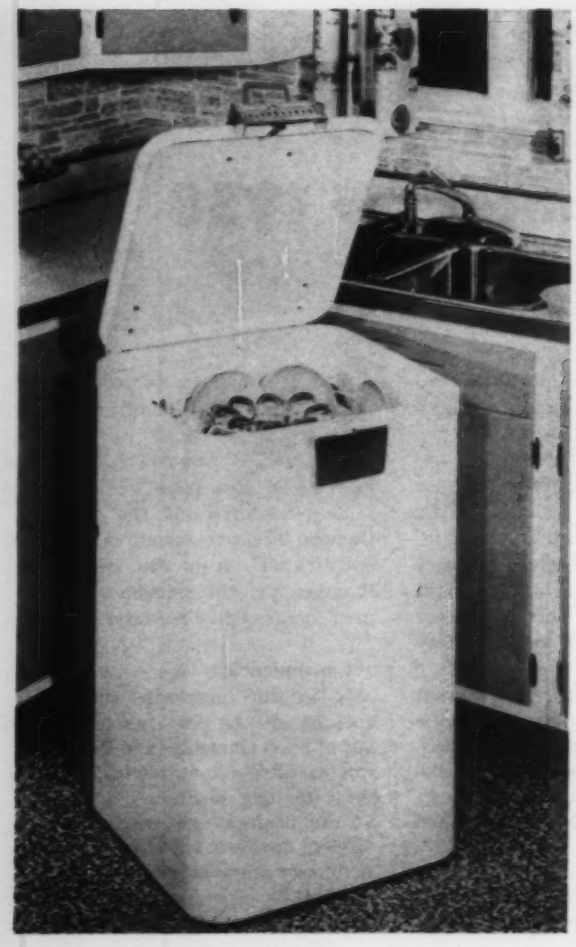


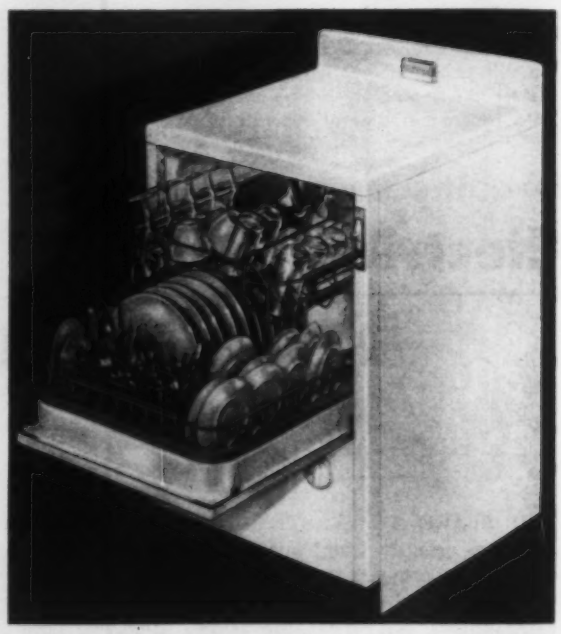
BENDING IS UNNECESSARY to use this GE wall-mounted 10.7 cu ft combination freezer and refrigerator. It features magnetic door closers, removable and adjustable shelves, miniature ice cubes, separate 2 cu ft freezer, sealed compressor, color styling.

"speed-heat" surface unit with controls which keep foods from scorching regardless of the size of the utensil or quantity of food. A similar device on Admiral Imperial ranges heats up at 2400 w for 10 to 15 seconds, then uses 1500 w for selected temperatures.

Certain Admiral and Frigidaire models have a built-in automatic griddle. Frigidaire's Custom Imperial range has a broiler with radiant walls claimed to operate fast and almost without smoke. An automatic rotisserie that folds flat when not in use is available in four Philco ranges.

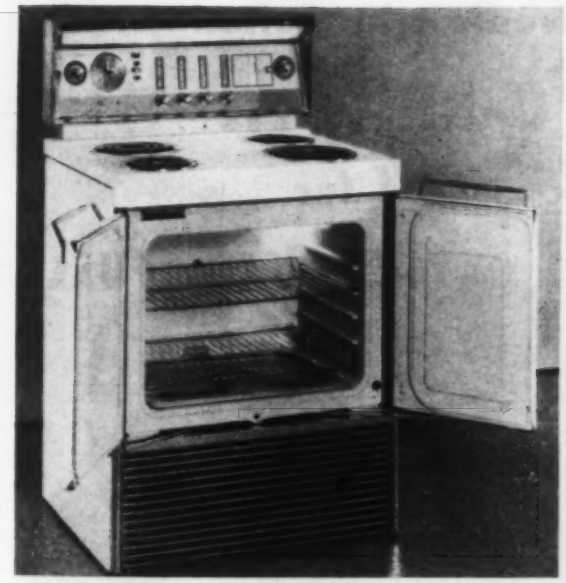
Controls: Greater numbers of automatic features call for a cor-



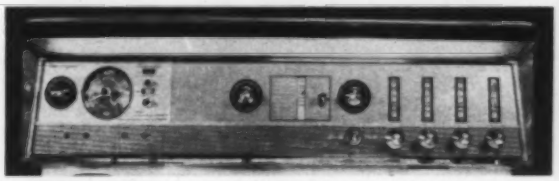


SERVICE FOR EIGHT is the capacity of this home dishwasher, made by Hobart Mfg. Co., available in free standing, undercounter, and combined dishwasher-sink models. Cycle includes: 1½-minute spray, 7-minute wash, 1¾-minute rinse, 1-minute rinse, 25½-minute dry. Water consumption is 9-1/3 gal per cycle. Centrifugal pump forces water through six jets in wash arm which revolves at 100 rpm in cabinet bottom. Dishwasher can be set to use only a portion of its cycle to warm dishes before meals.

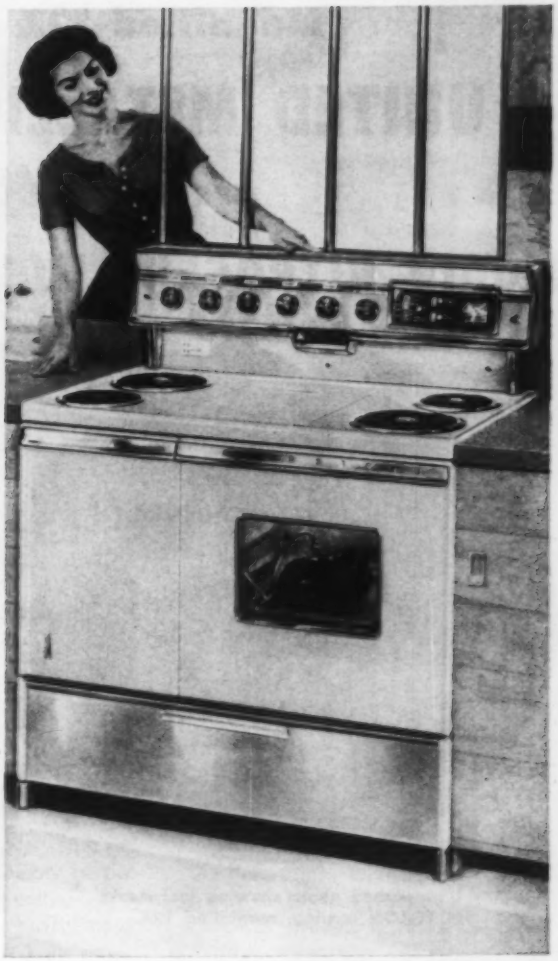
COUNTER-HIGH AND MOVABLE, this Westinghouse dishwasher (at left) holds a dinner service for eight. Complete washing cycle takes 33 minutes, consists of 1-minute prerinse, 10-minute power wash, ½-minute purge, 90-second power rinse, 1-minute drain, another power rinse, and a 16-minute power dry. A 750 w heater raises water temperature during washing, rinsing and drying. One cycle uses 6 gallons of hot water.



FRENCH DOORS on the oven distinguish this 30-in. wide model by Frigidaire. It has an automatic meat tender that senses and controls temperature inside a roast. Other features include fast heat-up surface units one of which is 8 in. with special control.



CONTROL PANEL of Frigidaire two-oven range is both functional and attractive. Oven controls at left include: Time signal, clock, elapsed time setter, hour-of-day to start oven, oven temperature knob, paired bake or broil buttons for each oven. Center cluster operates with meat tender device. Right cluster operate surface units, one of which is fast warm-up, another automatic.



ELITE MODEL in the Admiral line is this 40-in. wide range with auxiliary oven. It features recessed and divided top with built-in griddle, infinite number of temperature settings, automatic temperature controlled surface unit, automatic meat thermometer, automatic rotary roaster.

responding increase in controls. Most are thermal or elapsed-time types. Designers have diligently studied ways by which to best activate and display the controls. Pushbuttons, switches, and dials are all found on the same panels. The panels, themselves, are styled for convenience and appearance the same as instrument clusters in automobiles.

Safety: Accepting children as they are, designers have not made it harder to get into refrigerators, but easier to get out. Doors on all GE units are held closed by magnets—there are no mechanical latches. Spring-loaded rollers on Frigidaire door latches make them easy to open from the inside. Last year, Admiral refrigerators had interior doorknob-size releases that glowed in the dark.

Kitchens to Come: Still more automatic conveniences are forecast for the near and distant future. President of Westinghouse, Gwilym A. Price, sees the function of the refrigerator distributed among several distant centers in the home. Refrigerated drawers would be chilled by a system that uses neither conventional motors nor compressors. Electrical current would pass through a thermocouple junction to produce cold.

Mr. Price also sees a kind of "domestic automat." Packages of prepared foods would be stored in racks in a freezer below four ovens. Some time in advance of a meal, the housewife would select the menu—up to four foods—then press buttons and set a timer. At the proper time, each package of food would be moved automatically from storage to the ovens. All would be cooked and ready at the selected mealtime.

Industrial designers Lippincott and Margulies see king-size, domestic vending machines. One room in a house, they say, could be arranged for bulk storage of canned goods. At the press of buttons, cans would be delivered to the kitchen one at a time. Items would be replenished in bulk at long periods, annually, semiannually, or quarterly. Bills for the bulk buying could be paid the same way.

Magnified 12X reveals why Teflon* coated

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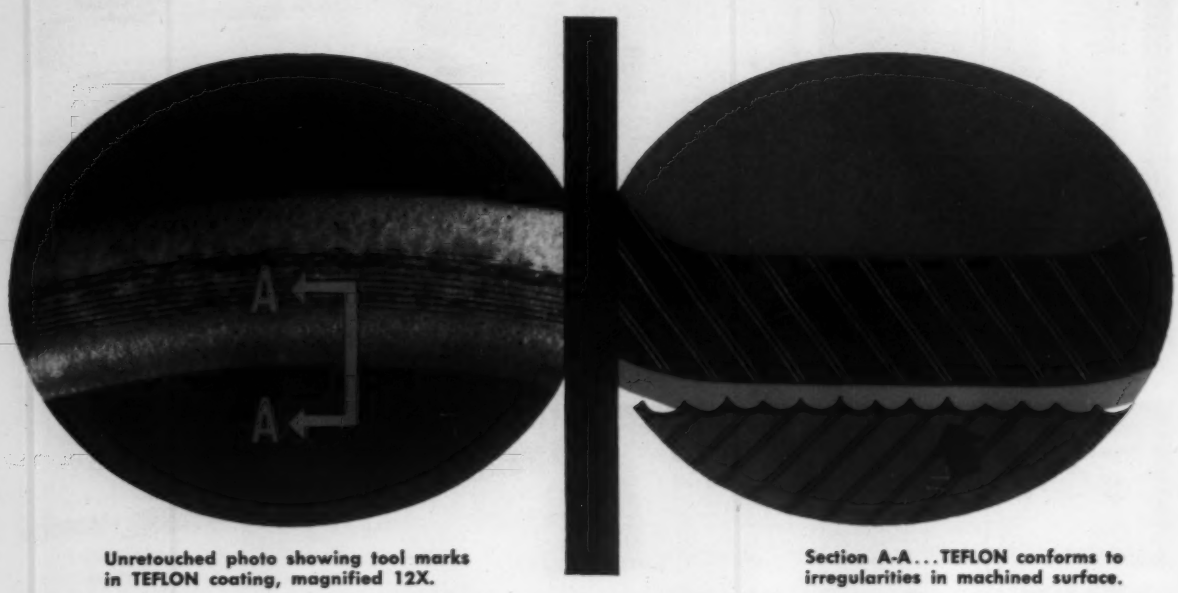

Unretouched photo showing tool marks in TEFLON coating, magnified 12X.

Section A-A...TEFLON conforms to irregularities in machined surface.

The 12X magnification proves that *Teflon*, permanently bonded to a United Metallic O-Ring, conforms to normal tool marks which it contacts in a machined seat. These microscopic valleys and ridges are exactly reproduced in reverse on the *Teflon* coating, as shown in photograph. This remarkable, non-porous, pliable coating compresses into these irregularities to help form a perfect seal.

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United Metallic O-Rings may be made to practically any required dimensions.

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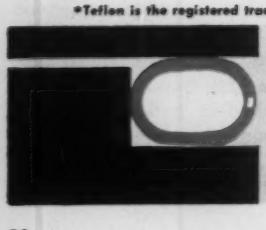

UNITED METALLIC "O" RING CORP.

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Photo courtesy of Daystrom Instrument Div., Daystrom Inc.

Engineer Your Planning

MOST EXECUTIVES recognize the value of planning and apply it with consummate skill throughout the company. An exception, however, is the engineering department, where workloads are shown to lack adequate planning. Engineering executives can profit, too, by co-ordinating decisions to a greater degree with other parts of the company.

For the company, planning means savings in costs and time. For the engineering department it means more meaningful work accomplished in shorter time.

Planning is one of two key areas where engineering productivity can be most improved, according to the survey, *Engineering Manpower,* on which these articles are based. The other area, leadership, will be discussed in a later article.

Four elements of planning are of first importance to daily operations of an engineering department: 1. Determining engineering objectives. 2. Evaluating work in process. 3. Scheduling work. 4. Expediting crash projects.

Determining engineering objectives

Most company officials readily agreed that planning work objectives is important. It is futile for an engineering department to spend time on projects for which there are no markets or on products which cannot feasibly be produced. A consultant contacted by the survey told of a company whose engineers had designed an explosionproof container. When judged from a technical standpoint the product was excellent, but there was no way to market it. Here, for failure to plan work objectives, the company suffered the loss of a good many manhours and a considerable amount of money.

One chief engineer admitted that it was the area which worried him most. Although few companies admitted that their engineers had been permitted to wander down blind alleys to waste time and money, almost all felt the danger to be ever present.

Determining work objectives is the delineation of a fruitful and profitable area for engineering investigation. This is middle ground between trying to regiment engineers to so great a degree that invention is retarded, or equally poor, loosening management reins to the point where technical personnel may stray into areas of purely academic, as contrasted with economic, significance.

A high degree of co-ordination between the various parts of the company is required. The chief engineer alone is not in a position to determine engineering objectives. It is most valuable if other company groups, such as the marketing department, can point out areas or ideas which would have potential.

Evaluating work in process

Answers to the survey indicate that many executives have feared grappling with the evaluation of engineering work in process. The apparent implication is that to be successful, the executive must be thoroughly familiar with the nature of engineering work, have considerable background, and carry to the evaluation an intimate knowledge of the persons involved. Another possible concern is that of regimentation. When queried, one executive literally drew back, "I'm afraid of it; the very last thing I want to do is stereotype the work."

Evaluating work in process is the area of planning which, according to survey findings, has thus far received the least attention of management. Analysis of the actual work that an en-

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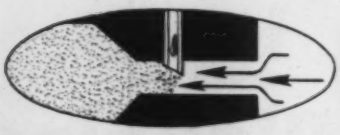

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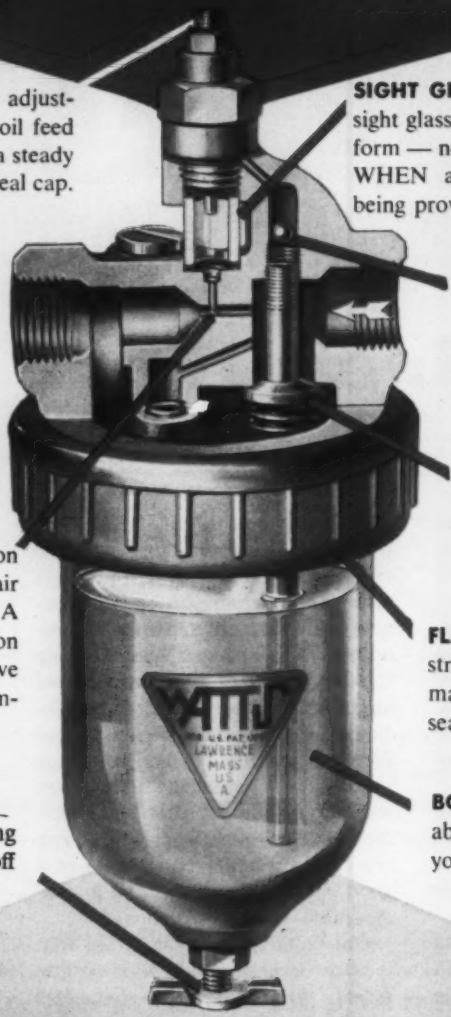

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gineer is performing differs from what is commonly called "job evaluation," which is simply the determination of what the man "is supposed" to be performing.

In evaluating work, the accent is on work elements that could be done better, possibly by other persons, or whether certain tasks need be done at all; i.e., the accent is on the nature of the work and not on evaluating the persons.

An electronics company executive reported that although work evaluation had been successful in breaking down some of their engineering problems into meaningful segments, other problems were also involved. After it had been determined what part of the work currently assigned to engineers could be performed by technicians or statisticians, it was found to be virtually impossible to hire as many as needed.

Also, the problem still remained of what shall be done by whom. Some rudimentary tasks of the engineering department are a vital part of the young engineer's training. Another part of the trick, then, is determining which tasks are valuable to the engineer and which are not. An executive of a large electrical equipment manufacturing concern emphasizes the importance of assigning challenging work:

> • Good utilization consists of matching the work with the individual engineer's ability to do the work and to find it continuously challenging. Utilization is zero if the purposefulness of the work is zero. It is a process of matching work, ability, and challenge.

Another executive when pressed as to just how he decides what nonengineering work is meaningful for his engineers conceded that, though critical, there is no formula in this area. His decisions are based on his own experience, which is varied. But as he sees it, he must insure that the "training will be to the best interest" of the people working for him and the work will be challenging.

The study shows that wherever work evaluation has been successful, it has almost always been made by the person in charge of the group. Success of the attempt to improve productivity was each time no better than the evaluator's abilities as a judge of men and engineering assignments.

As in other areas of increasing productivity, there are always engineering managers who would shrug it off:

> • I recognize the need for work evaluation, but for us it's just not practical; we are always behind schedule, working overtime, and too pressed to take the time that this would require.

Despite such a reply, it would appear that much more can be done in the area of work evaluation.

Scheduling work

In surveying companies about scheduling, it is found that their practices fall predominantly into one of two distinct groups: they either employ a thorough system of scheduling and rely on it, or do practically no scheduling whatever. There seems to be no middle ground.

Some systems were extremely thorough and complete. In one large firm, the vice president for engineering displayed charts that covered each project for the coming year. Complete in every detail, they broke each project down into segments and scheduled each segment through the various working groups in the department.

Some segments were scheduled for a period of weeks, others for hours only. As soon as the Board of Directors had approved a project and assigned to it a priority, it was broken down and scheduled as rapidly as possible. In this way, the executive was able to tell if his personnel could complete the job prior to the deadline. If the schedule appeared too tight, he had ample time either to "farm" out work or to try to hire added engineers.

For project scheduling and review, a small electronics firm uses top management personnel on a Project Specifications Committee to approve and schedule engineering work. Each engineer writes a weekly, brief report of his problems and progress, which are reviewed by the chief engineer and company president. Two advantages of this system are frequent review and the engineer's personal satisfaction in response to direct contact with top management.

Some companies appear to do no scheduling at all. One chief engineer said it is difficult for him to plan ahead because projects were not approved and for-

Checkpoints for Engineering Management

- ☑ **1. Is the engineering load planned effectively?**
- ☑ **2. Although engineering objectives may be well established within your department, are they coordinated with other departments?**
- ☑ **3. Who in your company determines what shall be done by the engineer and what is assigned to people of lesser or different training?**
- ☑ **4. Is the engineering workload scheduled and budgeted for an even flow through the department?**
- ☑ **5. How will you handle your next crash program?**

warded to him in time to permit any intelligent planning. He said, "When a project is given to me, I just pass it on to someone who is free, or nearly so, and he just finishes it when he can."

Companies that do a large amount of government work find it particularly hard to schedule in advance. Government contracts can be canceled or modified with only a minimum of notice.

Although scheduling seems generally to be effective at the level of chief engineer and top supervisor, the quality deteriorates sharply below this level. Group leaders and intermediate supervisors are generally not skilled in this area and seem to lack sufficient training to schedule effectively. Only few firms encourage these leaders and supervisors to use charts for their own projects and for assigning their people.

Periodic reviews of projects are generally felt to be of prime importance. By setting deadlines for each phase of a project, it is easy to determine when and where problems arise. Relying on one final completion date can have chaotic results if problems at various stages remain unsolved.

It was found that scheduling of the over-all engineering department normally falls under the cognizance of the top engineering executive in the company. Because of the complex nature of modern engineering, it is extremely difficult for those in management with nontechnical backgrounds to understand engineering projects or their scheduling.

Thus, little by little, the nonengineering elements of management seem to lose touch with the engineering department and become increasingly dependent on the abilities of their engineering executive. Often the success or failure of a scheduling system is solely a function of his abilities. Though other members of management can measure and value output, they have very little way of knowing whether the engineering department is being run efficiently or not. This problem appears to be central to the question of engineering productivity.

Expediting crash projects

Despite the most intricate and farsighted scheduling, many companies are frequently faced with "crash" programs. Such programs almost always waste engineering manhours. These can arise from externally or internally caused problems, or a combination of both.

Survey replies indicate that modifications in government contract requirements are very often the cause for crash programs. But even more often, poor project review systems are at fault. In some companies, there appears to be a tendency to let problems ride until suddenly they are recognized as crash programs. In other companies, where consistent, periodic review techniques exist, crash programs are rare.

However, it is apparently impossible to avoid some crash projects. One manufacturer went so far as to say he liked them because "they get the people on their toes." In a well-organized engineering department with a good system for handling crash programs, the effects of an occasional one are apparently salutary.

Many large companies, especially those operating under government cost-plus contracts, merely hire new engineers whenever they face crash situations. This avoids having to upset scheduled workloads, but creates problems when the jobs are completed, since most of these engineers are released after they have finished the rush projects. They often have trouble getting new jobs, simply because they have been released.

There were other more orderly systems uncovered by the survey. One particularly successful tech-

Recommendations for Management

1. Make Objectives Known

To ensure that engineers understand what the product objectives of management are, keep them informed. All too often this is not done, or else it is done inadequately. Consequently, individual engineers or engineering groups are not able to judge for themselves as they explore areas which are inconsistent with the needs of the company.

2. Encourage Engineering Comments

Through receptiveness and attention, encourage both suggestions and corrective criticism which members of the engineering department may have regarding their work, ideas, and problems. Unless this is done, management may lose touch with progress of the work it has assigned. New ideas, translatable into economically useful products, may be lost. Such comments may indicate areas properly in need of assistance.

3. Appraise Material Submitted

To monitor engineering progress, appraise, evaluate, and constantly co-ordinate with other departments of the company the material submitted for review and action by the engineering department. Do this as promptly as possible. Otherwise, projects that seem to point down blind alleys, opportunities for economic improvements, and problems which impede engineering work will inevitably continue to drain off revenue.

4. Review Projects Periodically

To ensure that opportunities for improving operations and engineering output, not noticed earlier, are weeded out, management is strongly advised to review all projects regularly.

nique used by several companies is to set up a special department for crash programs. One small company does this with great success and thereby allows its other engineers to work on a methodical, highly planned basis. Another firm has a few, very capable engineers who are always available for rush projects and aware of it. They normally do other work of low priority when not working on crash projects.

An executive of an airframe manufacturing company felt one advantage to having his engineers assigned to small working groups was that the supervisors would know the individual capacities of their men and could thus assign them to crash projects on an intelligent basis.

A medium-size firm charts out its engineering workload in man-hour estimates and keeps close control over the progress of each project by requiring frequent reports. This informs engineering management which of its engineers are in the best position to handle crash projects.

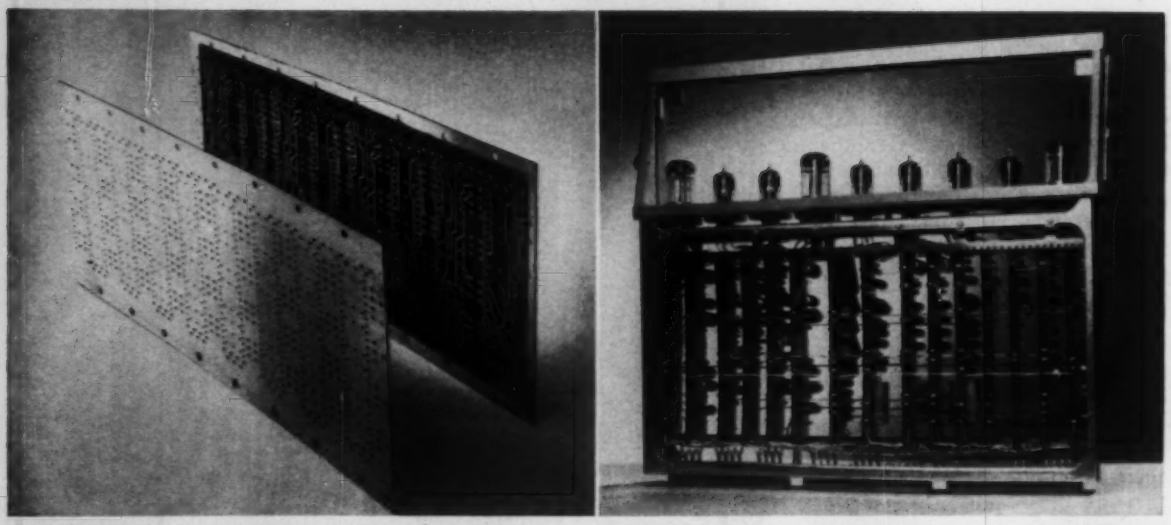
With regard to planning, the survey concludes that the criterion for management in planning work objectives is that, insofar as possible, the engineer's time must be spent on meaningful projects that fit into the company's overall objectives. The nature of the engineering load must be broken down and analyzed. Someone then has to decide what work will be performed by engineers and what will be handled by supporting personnel. It is recommended that this decision be made by a high-level member of the engineering management team. Once a project is accepted, a priority must be assigned, preferably by management. Work should be scheduled and budgeted. Progress charts and schedules should be used by the chief engineer. Adequate scheduling and budgeting, important to daily activities, can also greatly reduce the waste brought about by crash programs.

Next article in this series will appear in the Feb. 6th issue. It will deal with the hiring of engineers and discuss recruiting, application forms, and the role of advertising.

LARCENY IN EVERY MAN'S HEART is challenged by new dollar-bill changer. According to William A. Patzer, president of A.B.T. Mfg. Co. and inventor of the bill changer, "in some ways, it's easier to build an atomic reactor than a coin machine. . . The minute you put a new device on the market, there'll be people staying up nights trying to figure out a way to beat it." Describing principles of operation, the manufacturer is noncommital, says only that the mechanism is based on electronic principles; does not use a scanning technique. Artist's rendering shows contemplated, automated, 24-hr supermarket.

Growth potential of ultrasonics, cited as greatest in industrial drying, smog, and fog control, will be explored in concentrated research program. According to officials of Gulton Industries Inc., U.S. research has so far stressed high-frequency sound energy that can be transmitted through either solids or liquids. Europeans, however, have specialized in applications of ultrasonics transmitted through air in their research.

Believing ultrasonics-in-air is the key to growth potential, the company has announced French specialist Raymond Boucher will head up what is thought to be the first American research program in this field. Boucher holds eight main French and English patents in ultrasonics. His American patents have been purchased by the company as basis for study here.



THOUSANDS ON THOUSANDS of printed wiring boards are used in producing the SAGE computer for the nation's air defense. Produced by the International Business Machines Corp., the high reliability of these printed wiring boards is essential to the proper functioning of SAGE. At left is shown the prepunched panel before and after being printed; at right, a typical pluggable unit with components mounted.

Printed Wiring Boards Link Air Defense System

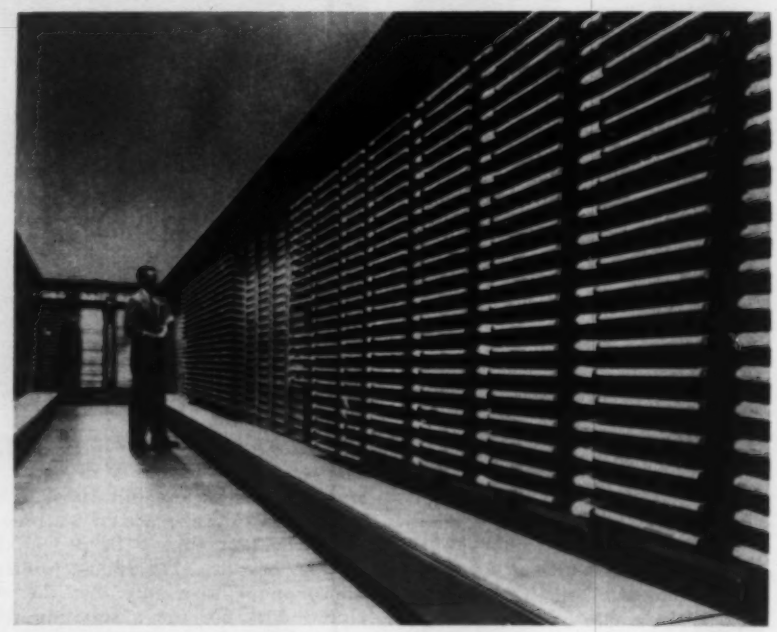
Versatile SAGE Computer Assembles Instant Air Picture

NEW YORK—Printed wiring boards and miniaturized components in Project SAGE, linked by telephone lines or radio to radar rings—on land, Navy picket ships, offshore Texas towers, and planes ranging far out to sea—can track hostile planes immediately and translate data into the over-all air situation in an instantaneous, graphic picture. Human decisions can then direct the most effective defense action to be taken.

Designed by the International Business Machines Corp. in cooperation with MIT's Lincoln Laboratory, the first machine was completed in mid-1956 in accordance with schedule. Many automated and semiautomatic manufacturing techniques are used in fabricating the electronic circuitry.

The computer automatically calculates for the operator the most effective employment of such weapons as guided missiles, anti-aircraft batteries, and jet interceptors. Intercepting jets can be controlled by radio directions fed directly from the computer to the automatic pilot in the plane. Missiles can be controlled similarly. At any time, the air battle commander can have the computer display the overall air situation or whatever part of it he wishes to monitor in detail.

Facilities are provided so that preventive maintenance can be performed on the machine while SAGE data continue to be processed. SAGE uses a magnetic memory.



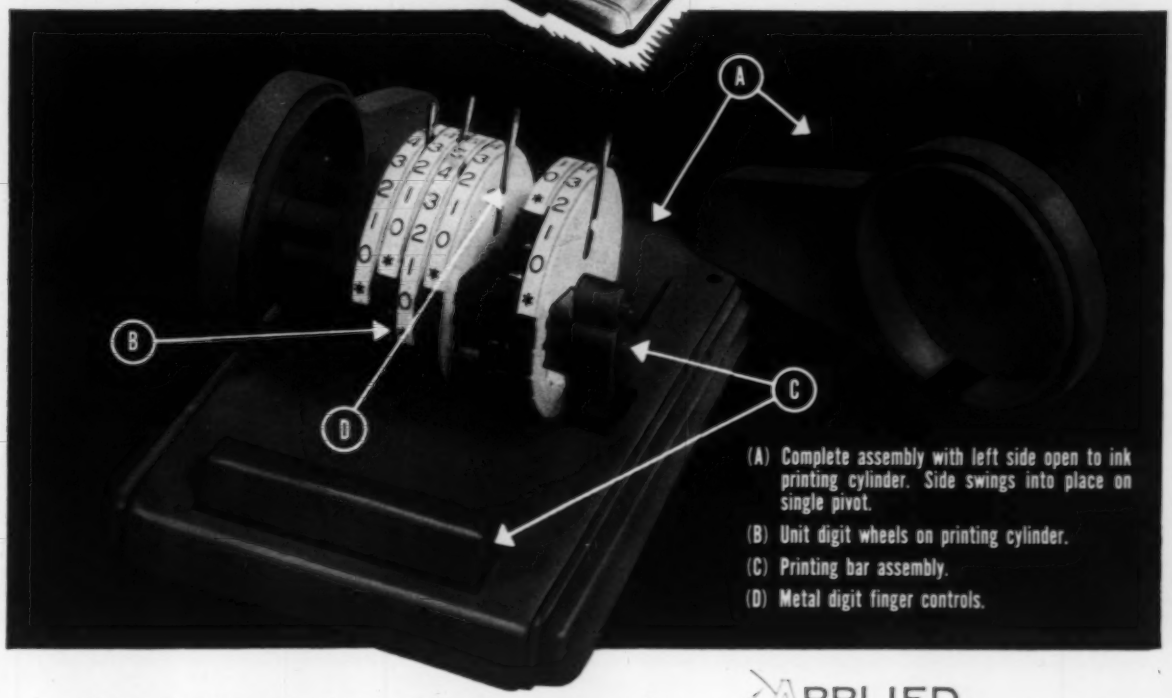
DENSELY UNITIZED SAGE computer is shown in part, with pluggable units installed. For pluggable units, copper-clad phenolic laminate panels are pierced, the pierced holes sensitized for plating, and the plating resist is dry-screened. After panel has been tin-lead plated, the resist is removed by vapor degreasing and the resulting exposed copper is removed by chromic acid etching. The tin-lead plating acts as an etching resist.

A semiconductor device has been developed which may replace relays and certain power industrial tubes. Called a silicon-controlled rectifier, the device has been developed by the General Electric Co. and is expected to find wide

(*Continued on Page* 41)

NEW PERMAPRINT CHECK PROTECTOR

Low Cost Check Protector


A
B
C
D
(A) Complete assembly with left side open to ink printing cylinder. Side swings into place on single pivot.
(B) Unit digit wheels on printing cylinder.
(C) Printing bar assembly.
(D) Metal digit finger controls.

Molded in Styrene *for* APPLIED RESEARCH CORPORATION

The new "Perma Print" Check Protector, marketed by The Applied Research Corporation, prints thousands of checks without re-inking. The result is completely professional and impressive in every way

This handy check writer had to be inexpensive, lightweight, sturdy and absolutely reliable. Its cost must be low to give small retailers, professional men and even householders check protection. Quinn-Berry engineers were chosen for this job.

Here you see illustrated the many molded styrene parts and their function in the complete assembly. Precision engineering backed up by dimensionally stable thermo-plastic molding proved to be the desired answer.

Again a Quinn-Berry achievement in an unusual molded plastic application . . proving, of course, that at Quinn-Berry the "Unusual is Routine."

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Circle 417 on Page 19

Circle 418 on Page 19→

Get dependable operation, increased

quality for your product . . .

GENERAL ELECTRIC TRI 55 CLAD MOTORS PROVE THEY PROVIDE IT BY PASSING TORTURE TEST

HERE'S HOW: G-E Tri/Clad '55' polyphase motors are more fully enclosed than ordinary dripproof motors. This extra protection makes them suitable for many jobs which normally require splashproof motors . . . extra protection at no extra cost.

Mylar* polyester film slot and phase insulation, non-wicking leads, and water-resistant stator coating give long-life protection against *moisture.* Formex† magnet wire provides protection against heat-aging and *dirt.* Heavy-duty bearing system keeps lubricant in, abrasive dust out. And rigid cast-iron frame and endshields and melamine paint finish protect G-E motors against *external damage.*

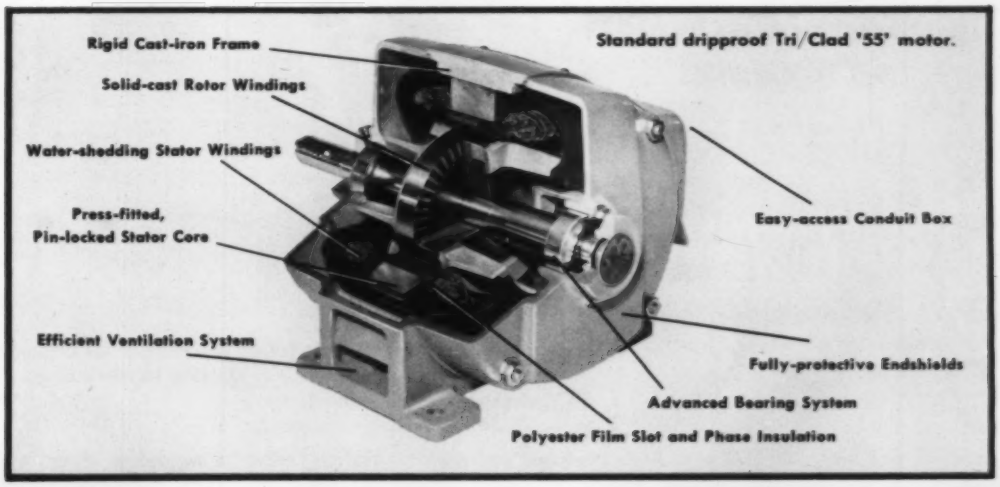
*Registered Trade-mark of DuPont Co.

These are just some of the outstanding Tri/Clad '55' motor features which mean longer life, more dependable operation—improve the quality and saleability of your product at no extra cost to you *or* your customers!

CONTACT your nearest G-E Apparatus Sales Office for *personal proof* on how G-E Tri/Clad '55' motors can give better operating protection to your products. And ask for your free copy of descriptive bulletins, GEA-5980 and GEA-6602, or write to Section 840-19, General Electric Company, Schenectady 5, New York.

†Registered Trade-mark of General Electric Co.

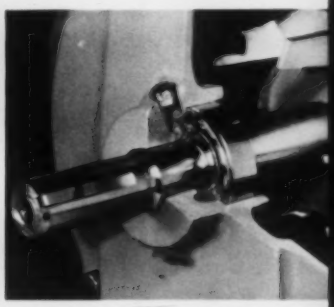
GENERAL ELECTRIC



Mylar Insulation protects against moisture; assures longer motor life, minimum maintenance.

Water-resistant Coating applied to every stator assembly virtually eliminates insulation failure due to moisture.

Formex Wire insulation will not break under severe conditions—protects against heat-aging and abrasive dust.



Long-life Bearing System seals dirt out, has new longer-lasting grease, can be regreased.

Born December 7, 1957... Already 70 Years Old...

with greater Facilities for serving YOU!

Leading manufacturer of air and vacuum power brake systems for trucks, trailers, buses and passenger cars, air controls, welding nuts and other products—

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veteran designer and builder of engineered atmosphere systems for all major industries —

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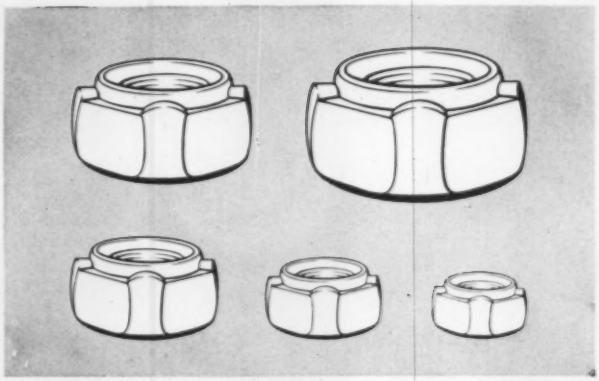
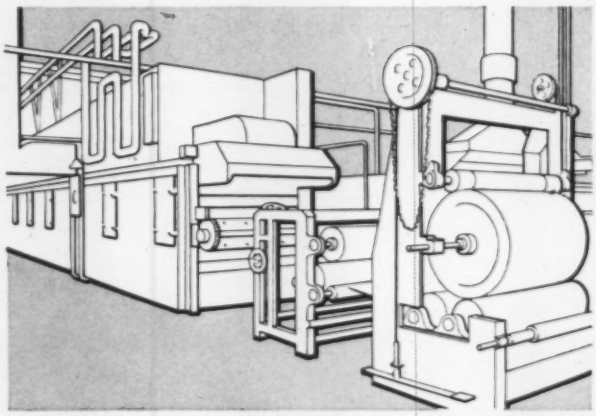
to form

MIDLAND-ROSS CORPORATION

with greater facilities, more manpower, and additional products to serve you, the customer!



Midland Welding Nuts come in a wide range of sizes



Ross Plastic Treating Line handles entire processing, from coating to rewinding.

Seventy years of combined business and development experience are now available to present and future customers of Midland-Ross Corporation, with its 6500 employees, 10 manufacturing plants, and $100,000,000 sales volume.

While each division will continue a decentralized form of operation, there will be substantial pooling of engineering talents for research and development, resulting in accelerated improvements in M-R's products and services.

We will welcome — and appreciate — every opportunity to serve you.

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Including John Waldron Corporation • Midwest Fulton Corporation • Ross Engineering of Canada, Limited Andrews & Goodrich, Incorporated

WHIRLY JET, the Alouette II turbine-powered helicopter manufactured in France by Sud Aviation, will soon be assembled in the U. S. by Republic Aviation Corp. The five-place, medium-range (345 mi) Alouette is powered by a 360-hp gas-turbine engine. It held the world's helicopter altitude record of 26,931 ft. Advantages of the turbine engine: No engine warmup time, higher power-to-weight ratio, better high-altitude performance, no engine vibration, and instant power response. The craft can stay aloft more than 3 hr and will climb at 2400 f.p.m. Possible jobs: Fire engine, ambulance, aerial bus, and ranch wagon.

(*Continued from Page 36*)

use as a combination electric-power relay switch and conversion device.

Applications for the new device are listed as replacement of power transistors in guided missile power supplies, replacement of thyratron tubes in commercial welders, use in industrial motor-control circuits for speed regulation, use as motor control for automatic machine tools, and replacement of relays in large industrial switching panels for controlling power distribution, chemical processing, and other functions.

Smuggler Supplies Government With Diamond Pressure Chamber

Sample in Huge Gem Scanned by Infrared Rays

WASHINGTON—Using a flawless, 7½-carat diamond confiscated from a smuggler, government scientists are conducting important experiments. A needle-sized hole drilled through the gem is used for testing materials at pressures up to 450,000 psi.

The diamond serves as a pressure chamber at the National Bureau of Standards in studies of materials under great heat and stress. Through its clear sides, changes in a sample of material are scanned under infrared rays.

After the diamond was seized by the Bureau of Customs, it was eventually turned over to the National Bureau of Standards. It is a rare and perfect stone, much superior to common diamonds for this particular scientific purpose. Originally it was cut in emerald shape, but NBS scientists, who are carrying on high-pressure, high-temperature research in the mineral products division, had it modified for their work. The diamond was flattened on two sides and the bottom, and drilled lengthwise with a hole 0.015 in. in diameter.

Two tiny pistons of hard tool steel are inserted, one from each end, with the sample to be investigated between them. The diamond is placed in a hydraulic press and surrounded by an induction heating coil. Because of the tiny dimensions of the pressure cell, it is necessary to apply a weight of about 80 lb to bring the internal pressure to 450,000 psi. Pressure above that might split the diamond.

The first experiments in the diamond have been started with quartz and other materials containing silica.

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Circle 420 on Page 19

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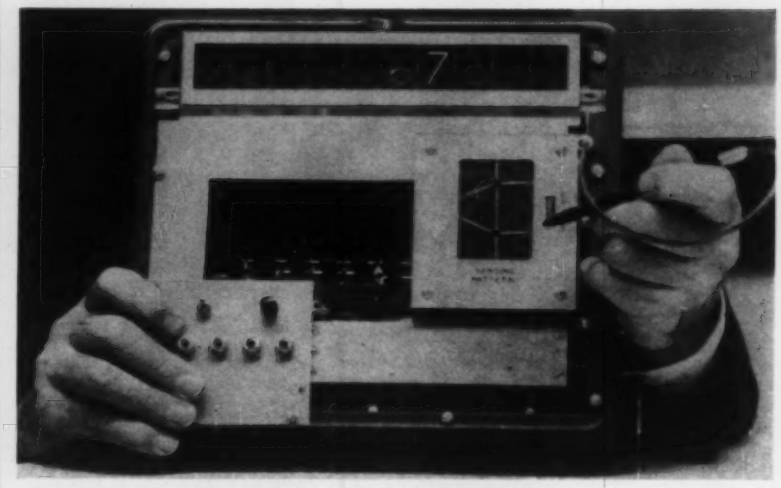


Experimental device reads handwritten numbers. Metal stylus points to the writing area. The machine can recognize numerals as they are written.

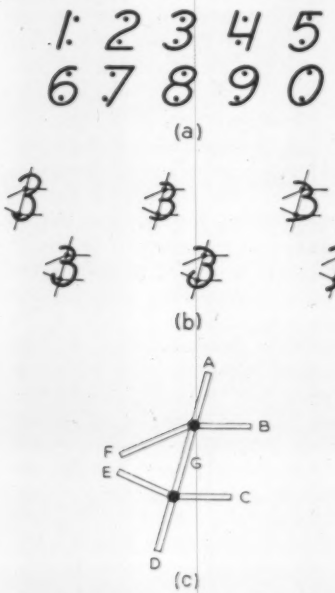
Machine Reads Handwritten Numerals

Device Can Be Applied To Read Handwriting

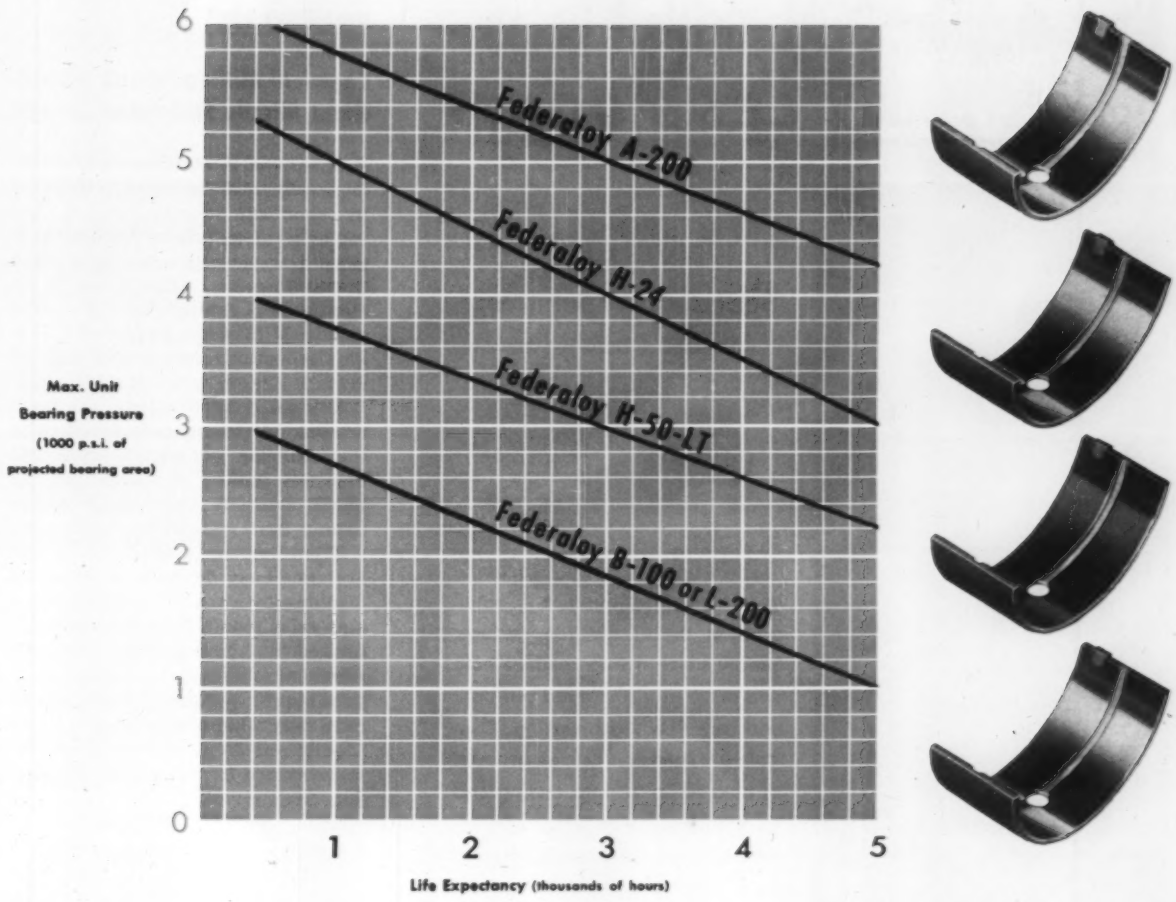
NEW YORK—An experimental device the size of a portable typewriter can read handwritten numerals. Invented at Bell Telephone Laboratories' System Engineering Dept., the machine may eventually become a valuable addition to telephone offices. With some modifications the equipment could be used to read handwritten letters.

The machine recognizes numbers as they are being written and indicates the numeral by lighting up the correct digit on a numbered panel. The writing is done with a metal stylus on a specially prepared writing surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from these two dots. Numerals are recognized by the machine, depending on which lines are crossed. To clear the device for the next number, the writer touches the stylus to a special plate which causes the previous number to be "erased."

Information as to which vectors have been crossed by the metal stylus is transmitted to a translator. Since each numeral has a unique set of crossings, the translator need only distinguish among them to produce a different output for each numeral. The outputs, fed to the utilization circuit, illuminate a number, operate a teletypewriter, feed the information to a computer, or perform any other desired operation.



Experimental device which reads handwritten numerals depends on two-dot constraint which serves to guide the formation of numerals. Wide variations may be made in forming numerals. The circuits would properly record any of the forms shown as a 3. Crossing any combination of seven radius vectors sends information to the translator and logic circuits, which decode the numeral being written or read.



These alloy linings cover 95% of engine bearing requirements

With a steel back and one of these lining alloys—tin- or lead-base babbitt, medium or heavy-duty copper alloy—or extra heavy-duty aluminum alloy—95% of sleeve bearing requirements can be met with complete satisfaction in performance results.

Whether your bearing is a new design or re-design of an existing application, consultation with our Engineering Department may result in tooling advantages.

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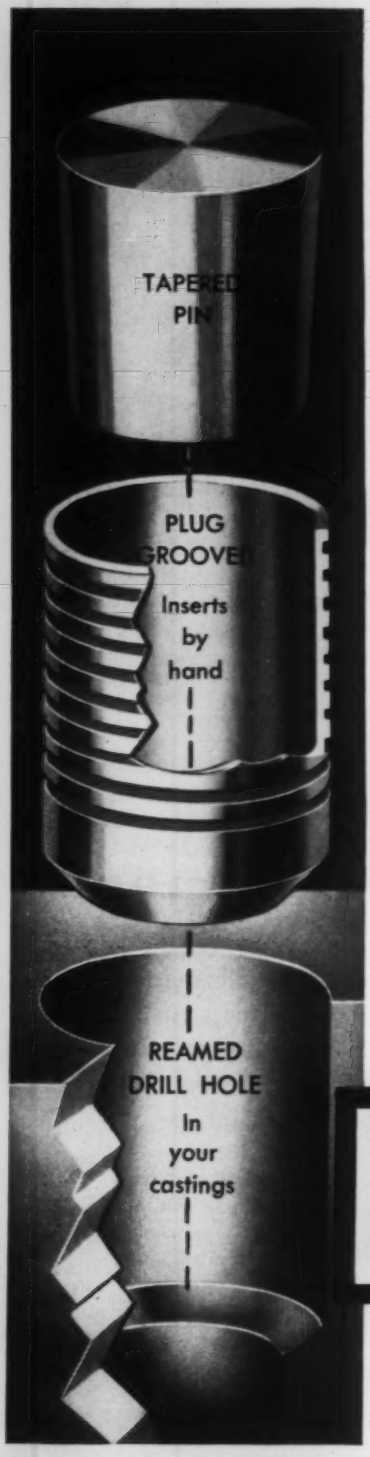

NEW PIN-PLUGS*

Seal simply, positively Prevent costly leaks!

Now — forget conventional, costly methods of sealing holes that serve as flow or pressure passages. The Lee "Pin Plug" is a cylindrical plug with a tapered reamed hole partway through its center and numerous small grooves on its outside surface. Simply place it into reamed hole and drive in the tapered pin until ends are flush with casting. Controlled expansion causes grooves in plug to "bite" into casting and form independent seals and retaining rings. Extensive laboratory tests report no leaks under normal pressures, often show bone dry seals up to pressures of 40,000 psi.

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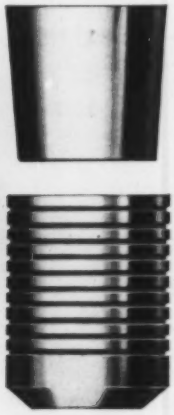


*PAT. PENDING

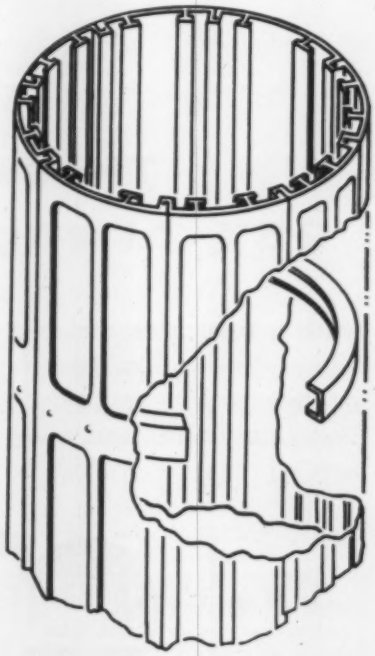
THE LEE COMPANY WESTBROOK, CONN.

Chemical Milling Forms Giant Missile Structures

MANHATTAN BEACH, CALIF.—Large, integrally stiffened panels, shaped by chemical milling, extend the use of light metals in the design of missile structures. At the United States Chemical Milling Corp., an outstanding example is the use of panels 3 ft wide and over 25 ft long milled to tolerances of ± 0.003 in.

For some applications, the shell formed by the panels constitutes the exterior of missile fuel and oxidizer tanks; hence, is an integral part of the missile structure.

Titanium and supersteel alloys are extremely difficult to form and machine in a conventional manner, and as a result have been greatly limited in their applications. By chemical milling, however, it is possible to produce panels in almost any shape or contour.



Shaped by chemical milling, eight panels are interlocked to form a cylindrical shell used for the body of a long-range ballistic missile. Missile fuel and oxidizer tanks, being cylindrical in shape, fit neatly inside the shell. For some uses, the shell forms exterior of the tanks.

Missile Master Directs Nikes

Air Defense System Guards Washington-Baltimore Area

WASHINGTON—The first fully operational, air-defense control system in the U.S. was recently placed in operation at Fort Meade, where it will guard the Washington-Baltimore area against attack.

The Missile Master is an electronic system which controls and co-ordinates the fire of the Army's air defense weapons. It electronically stores all information on targets in the area, presents a TV-like pictorial display, and preselects targets in an attacking air fleet for destruction by individual batteries of a Nike network.

Though the Missile Master can operate independently, it works in conjunction with the Air Force SAGE control system. Target information available to the SAGE system is passed on to the Missile Master. When SAGE information is unavailable or incomplete due to technical difficulties, Missile Master tracking operators can generate data of their own from the local surveillance radar.

According to Army announcement, the next Missile Master system to become operational will be for the New York City defense area. Similar installations at other strategic population and industrial centers across the nation will follow.

Combat Observation Methods Placed Under Study

Cornell to Review, Improve Surveillance Systems

WASHINGTON—Combat surveillance methods, the continuous watch over a battle area under all conditions of weather by day and night, will be re-examined under a contract recently awarded by the Army. In a two-year program, Cornell Aeronautical Laboratory is slated to study systems of surveillance of a battlefield by radar, infrared, sonic, meteorological, drone

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  Carter maintains complete spare parts and experienced engineers in 40 different locations throughout the United States, Canada, and Mexico.
- **PHONE 24 HOURS A DAY**
  Call in your order any time of the day or night. Carter will take your order and begin processing it right away.

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AIR CYLINDERS • AIR VALVES • HYDRAULIC CYLINDERS
ROTARY ACTUATORS • SPECIAL CONTROLS

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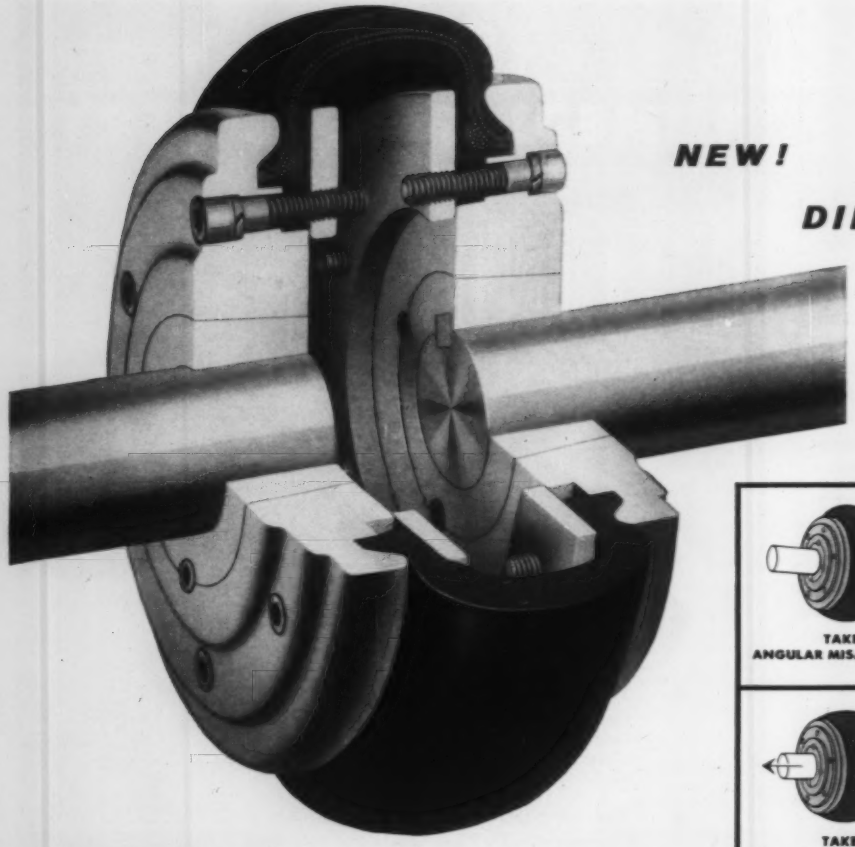
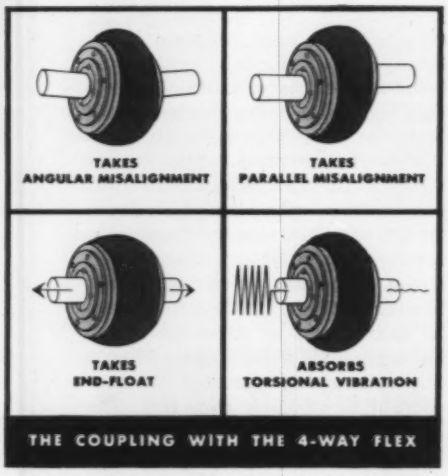


NEW!

DIFFERENT!



DODGE

Para-flex

FLEXIBLE CUSHION COUPLING

THIS coupling "swallows up" shaft misplacements. It automatically compensates for end-float, parallel misalignment, angular misalignment *or any combination of all three.* Moreover, it cushions the stresses of shock loads. And it absorbs torsional vibration—reducing noise and protecting machinery from vibration's destructive forces.

Here is a new type of performance—made possible by the development of a tire-like flexing element. Synthetic tension members, bonded together in rubber, give this element the stamina and dependability of modern, high-speed, high-load, shock-absorbing truck tires—and the ability to respond magically to all manner of changing shaft conditions.

Para-flex takes minimum space on the shaft. Mounting is simplified through the use of standard Taper-Lock bushings—no reboring, no machining. Safety is promoted by flush design; there are no protruding parts. No lubrication is required, no periodic inspection. And since the flexible member is molded with a transverse split, it can be replaced *without moving either the driver or driven machine.*

Para-flex Couplings are stocked by Dodge Distributors in popular transmission sizes. They are available from factory stock in capacities up to 825 hp at 1200 rpm. Call your distributor for early delivery to *make your own test.* You'll witness something revolutionary!

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CALL THE TRANSMISSIONEER, your local Dodge Distributor. Factory trained by Dodge, he can give you valuable assistance on new methods. Look for his name under "Power Transmission Machinery" in the yellow pages of your classified telephone directory—or write us.

reconnaissance, photographic, and televisual means.

Such information is essential to Army commanders who may operate on battlefields covering thousands of square miles and employ the far-reaching weapons of modern warfare. For example, a target for a guided missile might exist for only a brief period at a distance of hundreds of miles. A commander must be able almost instantly to scan a large battle area, locate and identify the potential target, prepare missile guidance information, launch a missile, and verify results.

The study of combat surveillance undertaken by Cornell is a three-fold task:

1. Evaluate all major programs of surveillance within the Army.
2. Review tactics and techniques in relation to current and future combat surveillance programs.
3. Recommend new policies and practices.

Meetings

AND EXPOSITIONS

Feb. 4-6—

Society of the Plastics Industry Inc. 13th Annual Technical and Management Conference of the Reinforced Plastics Div. to be held at the Edgewater Beach Hotel, Chicago. More information is available from society headquarters, 250 Park Ave., New York 17, N. Y.

Feb. 13-15—

National Society of Professional Engineers. Spring Meeting to be held at Michigan State University, East Lansing, Mich. Further information is available from NSPE headquarters, 2029 K St. N. W., Washington 6, D. C.

March 3-6—

American Society of Mechanical Engineers. Gas Turbine Power Div. conference and exhibit to be held at the Shoreham Hotel, Washington, D. C. Further information is available from Mr. Barry Freer, 1300 Connecticut Ave. N. W., Washington 6, D. C.

March 4-6—

Society of Automotive Engineers Inc. Passenger Car, Body and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 11-14—

Pressed Metal Institute. Spring Technical Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 17-18—

Steel Founders' Society of America. 56th Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 17-20—

American Society of Mechanical Engineers. Aviation Div. Conference to be held at the Statler-Hilton Hotel, Dallas. Additional information can be obtained from ASME headquarters, 29 West 39th St., New York 18, N. Y.

March 17-21—

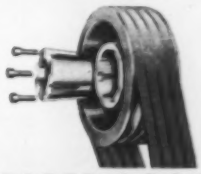
National Association of Corrosion Engineers. Fourteenth Annual Conference and Exhibition to be held at the Civic Auditorium, San Francisco. Further information is available from association headquarters, 1061 M & M Bldg., Houston 2, Tex.

"If there's one thing I can't stand it's sharpening pencils."

DODGE PRODUCTS you should know

DODGE-TIMKEN

America's Quality Pillow Blocks!



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Easy on — easy off! Mount flush!

TAPER-LOCK SPROCKETS

No reboring — no waiting!

Write for Bulletins!

- Roller Bearings. Load ratings, dimensions, etc. Bulletin A-638.
- Taper-Lock Sheaves. Drive tables and technical data. Bulletin A-661.
- Taper-Lock Sprocket and Dodge Roller Chain data. Bulletin A-644.

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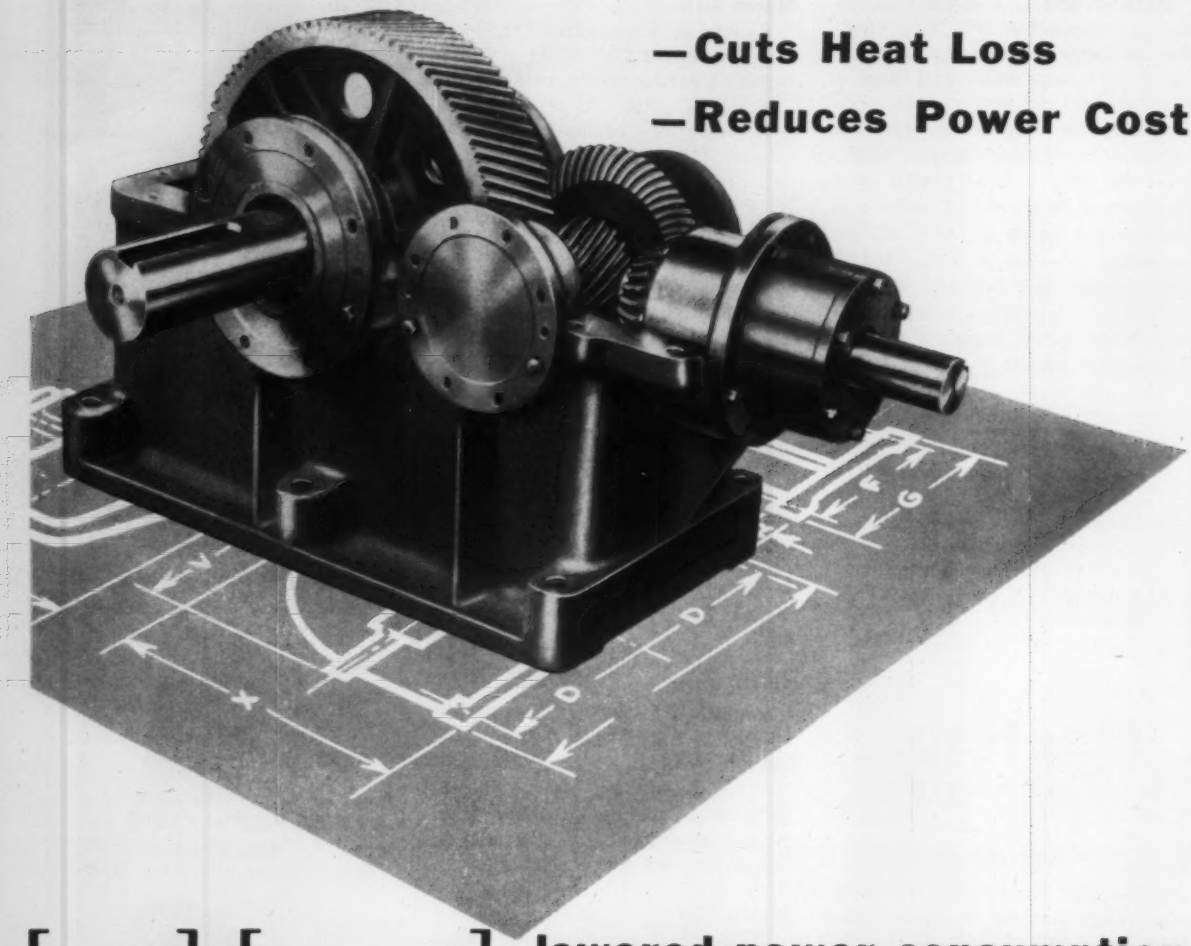
Circle 426 on Page 19

Maximum Efficiency In Right Angle Drives

—Cuts Heat Loss

—Reduces Power Cost



[advanced design] + [manufacturing skill] = **lowered power consumption and reduced prime-mover cost**

A glance at the illustration will readily convince you of the plus features of these quality "custom-built" units. Spiral-Bevel and Helical Gearing assures quiet operation at high speeds, and increased tooth strength. Pinion shafts are integral with gears and finished to close tolerances by grinding. Ball or Roller Bearings support shafts and are designed to take combined radial and thrust loads. Housings are quality grey cast iron with all points of stress properly ribbed to reduce deflections and stresses to minimum; also housing design provides adequate oil reservoir and large radiating surface for thermal capacity. Vertical Units are also available, and are equipped with "dry well", which keeps oil from leaking at low speed shaft.

Hundreds of Philadelphia Spiral-Bevel Helical Units are used throughout Industry, driving Paper Mill Machinery, Conveyors, Blowers, Fans, Machine Tools.

Philadelphia Spiral-Bevel Reducers may be had in Horizontal or Vertical Types; Single, Double or Triple Reduction types, to meet every possible requirement.

Send for complete Catalog #SB-57, which describes all types of Horizontal and Vertical Spiral-Bevel Helical Units.

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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Virginia Gear & Machine Corp. • Lynchburg, Va.

Circle 427 on Page 19

hold everything!

Ingenious invention backed by years of research have produced many time - proved proprietary items.
CABUCKLE
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special fasteners for every purpose
There is a V-S Fastener of GUARANTEED STRENGTH to suit your exact need. No matter what the requirement . . . what the configuration . . . what the material . . . your best source for aircraft fasteners is VOI- SHAN
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U. S. Army Redstone Missile

THE *FORWARD* LOOK

CHRYSLER CORPORATION

BRUNING Reproduction Machines help Chrysler Corporation in Vital Missile Work!

Most of the great work that Chrysler Corporation is doing in missiles must be classified for security reasons. It is no secret, however, that this progressive firm — creators of the advanced "forward look" in automobiles — has played a vital role in the development of the ballistic missile indicated above.

It is no secret, either, that Chrysler Corporation utilizes the outstanding advantages of modern Bruning Copyflex diazotype reproduction machines in this important work. Shown here is the imposing battery of Copyflex machines employed by the Chrysler Corporation. You can see for yourself the famous problem-free installation of Copyflex — no exhaust venting, plumbing, or auxiliary equipment. You can see, too, how Copyflex provides busy operators with such advantages as roomy feed tables, extra-large, convenient stacking trays.

And that's only part of the story. You, like Chrysler Corporation, should be benefiting by such modern Copyflex advantages as greater mechanical speeds, faster return of originals, synchronized exposure and development, automatic separation of originals from exposed prints, automatic stacking, and front-or-rear print delivery.

If you're not getting these important advantages, then every day you delay getting modern Copyflex is costing you time and money. Make the experience of Chrysler Corporation your basis for mailing the coupon below. You'll be glad you did!

Shown here is the impressive battery of Copyflex machines used by Chrysler Corporation for important reproduction operations in vital missile work. Machines need no venting, plumbing, or auxiliary equipment . . . provide Chrysler Corporation with important operating benefits.

Copyflex Gives You All These Advantages

Greater Convenience of Operation! Modern Copyflex gives printing widths up to 54" to simplify feeding of large tracings, facilitate multiple feedings. Such features as extra-large delivery trays, automatic separation, and front-or-rear delivery further speed operator's work.

Faster Mechanical Speeds! New Copyflex models introduced within the past two years offer sharply increased speeds — up to 30% faster than before. Synchronized exposure and development assure top quality prints, one knob control simplifies operation.

Sharp, Uniform Prints! Developing solution is applied *directly* to exposed print assuring complete, positive development at all speeds and on all types of materials.

Problem-Free Installation and Operation! Clean, quiet, odorless . . . Copyflex requires no vents or plumbing, needs only an electrical connection for operation. Precision-engineered design, including use of selenium rectifiers instead of troublesome vacuum tubes, assures trouble-free operation.

BRUNING Copyflex

Offices in Principal U.S. Cities

Charles Bruning Company, Inc., Dept. 13-K
1800 Central Road, Mount Prospect, Illinois
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Please send me information on the Copyflex process and Copyflex machines.

Name_____ **Title**_____

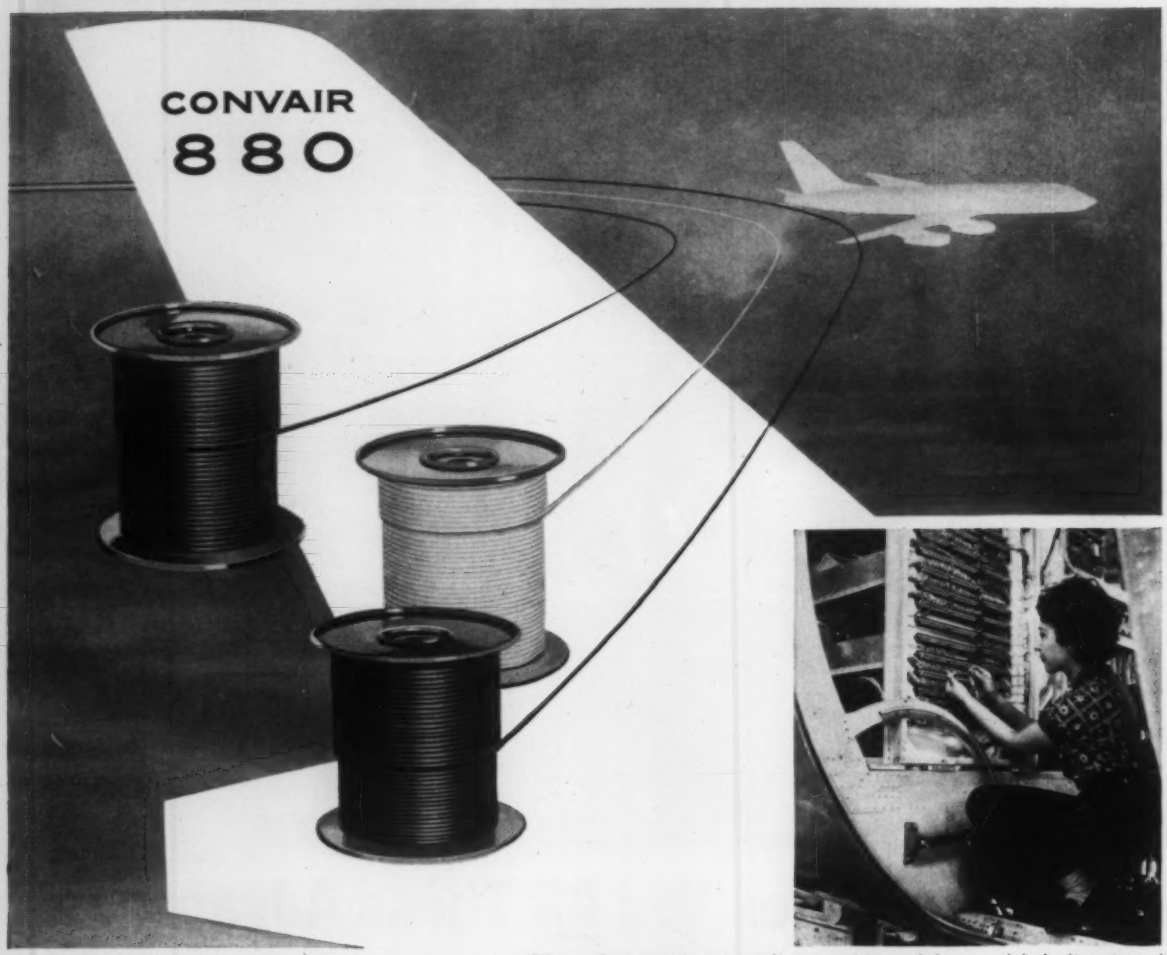
Company_____

Address_____

City_____ **County**_____ **State**_____

Another new development using

B.F.Goodrich Chemical *raw materials*



The new Convair 880 jet passenger liner uses wiring made by many of the leading wire and cable companies. B.F.Goodrich Chemical Company supplies the Geon polyvinyl material only.

15 MILES OF GEON HELP JET-LINER BEAT THE HEAT

MOVING East to West just a step behind the sun, this new jet passenger liner will make it from New York to Los Angeles in 4 hours 32 minutes. Hard at work inside this plane of tomorrow will be wire whose 15 miles of tough insulation is made of a unique new Geon polyvinyl compound.

Why Geon Was Chosen—Geon 8800 compound has 5 *times* the insulation resistance of previously available insulations over the full operating temperature range. The exceptional heat stability of Geon 8800 provides the superior performance required for jet aircraft wiring. These properties offer advantages as well for appliances, computers, machine wiring and similar applications.

How We Can Help You—Versatile Geon polyvinyl materials, in addition to providing flexible electrical insulation, are used for rigid piping and valves, protective coatings for steel, paper, upholstery. B.F.Goodrich Chemical supplies hundreds of types of resins, plastics, latices, and polyblends tailored to specific uses.

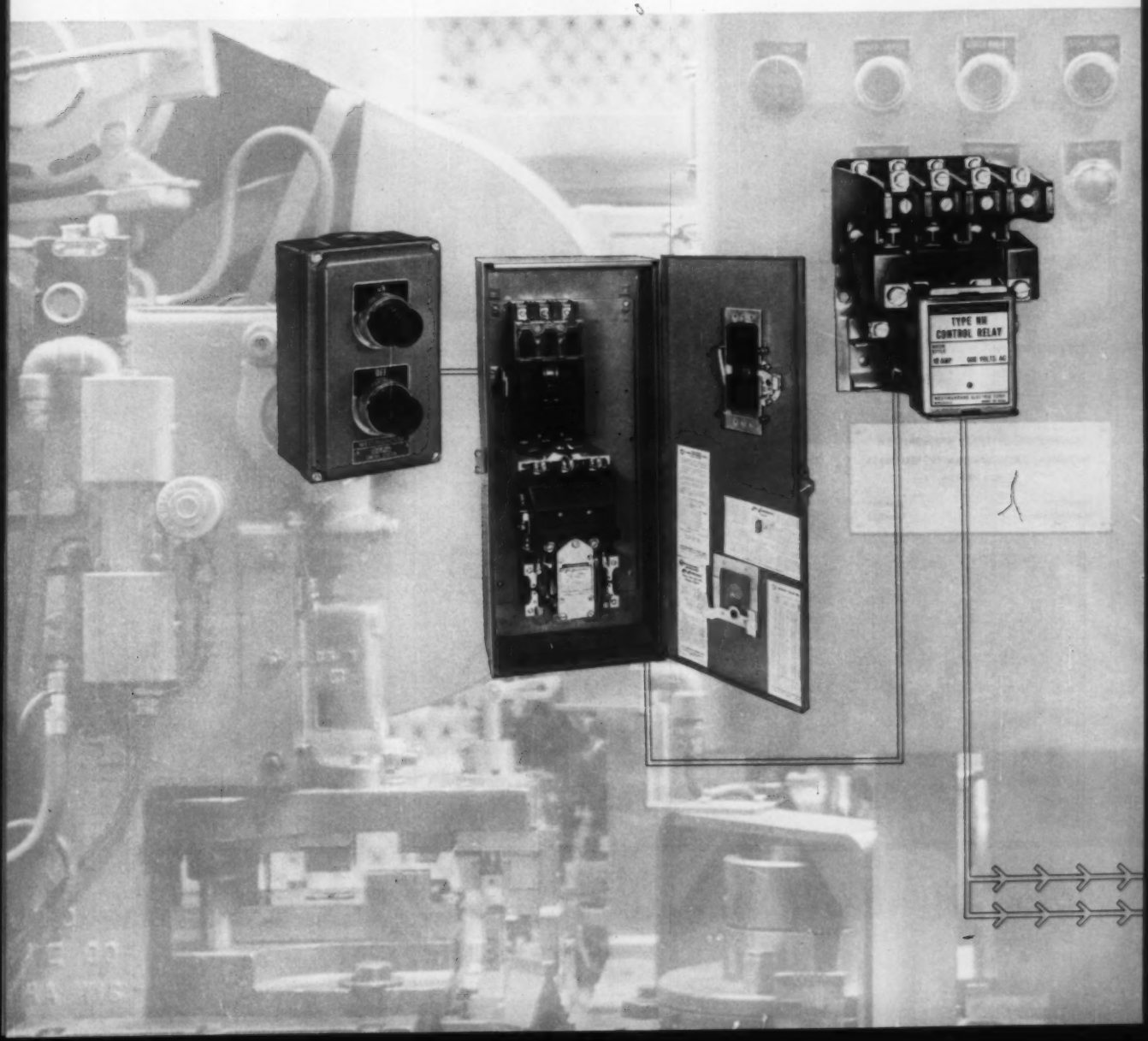
For information on applications write Dept. LO-1, B.F.Goodrich Chemical Company, 3135 Euclid Ave., Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

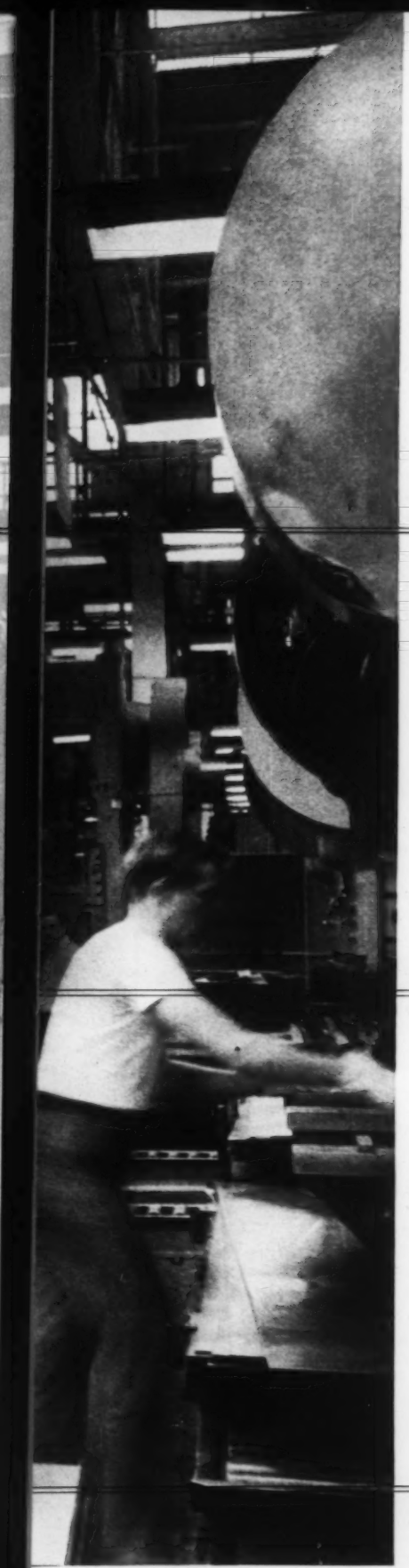
B.F.Goodrich **GEON polyvinyl materials • HYCAR American rubber and latex • GOOD-RITE chemicals and plasticizers • HARMON colors**

WESTINGHOUSE FOR CONTROL

Westinghouse matched control for machine tools



PUSH TEST
WESTINGHOUSE
ON
OFF
WESTINGHOUSE
TYPE NN
CONTROL RELAY
10 AMP
600 VOLTS AC



Westinghouse Push-to-Test and Pushlites

MAKE CONTROL PANEL SPACE WORK TWICE AS HARD

The Westinghouse Pushlite—a pushbutton plus an indicating light—means you need only half the usual number of units per panel. Frees up to one-half of your control panel for other units, other functions.

Matter of fact, you can make this same panel work *many times* harder with the newest addition to the Westinghouse line—a double-pole, double-throw contact unit that gives you twice the use from a single Pushlite! You can't beat that for space economy—just as you can't beat Westinghouse for Pushlite quality.

For added savings, use Westinghouse Push-to-Test indicating lights. They take the guesswork out of indicating light failures—simply press the light to find out whether bulb (or circuit) is out of order. (As you'd expect, both Pushlite and Push-to-Test are Westinghouse developments.)

Westinghouse Life-Linestarters

RUGGED PERFORMERS FOR RUGGED-DUTY APPLICATIONS

Tested on the toughest jobs—in saw mills, cement factories, chemical plants—these Westinghouse Life-Linestarters* have proven to be industry's most dependable performers. There are good reasons for this superiority, of course. Westinghouse Life-Linestarters feature all front-removable parts for fast, easy maintenance.

And additional auxiliary interlocks which can be added to all starters to handle additional loads.

Then there's the exclusive positive-break, bimetallic disc overload relay—gives you the option of hand reset, automatic reset or no-stop operation. (Available with an auxiliary normally open bell alarm contact.)

And the knife-edge fulcrum that prevents armature sticking or binding.

And the exclusive Westinghouse De-ion® arc quench grids that eliminate contact burning and pitting.

And much, much more—

*Trade-Mark

Westinghouse Relays

ASSURE YOU MILLIONS OF OPERATIONS WITHOUT A SINGLE FAILURE

And here's a relay that will match—operation for operation—any relay on the market today. It's good for millions of operations—*to meet the most demanding* machine tool specifications for reliable, long-life relays.

That's why you just don't go wrong when you specify Westinghouse Relays.

By the way—did you know that the bearing parts of the NH Relay are case-hardened to provide tough, wear-resisting surfaces for longer operating life?

That they're available in any combination of normally open or normally closed contacts from two to six poles?

That for applications where space is critical, the new compact Z Relay—double-pole, double-throw—offers extraordinarily long life?

For the whole story on Westinghouse Controls, contact your nearby Westinghouse sales office. Or write for bulletins B-7073, D-B11-000, and B-6749, Standard Control Division, Westinghouse Electric Corporation, Beaver, Pennsylvania.

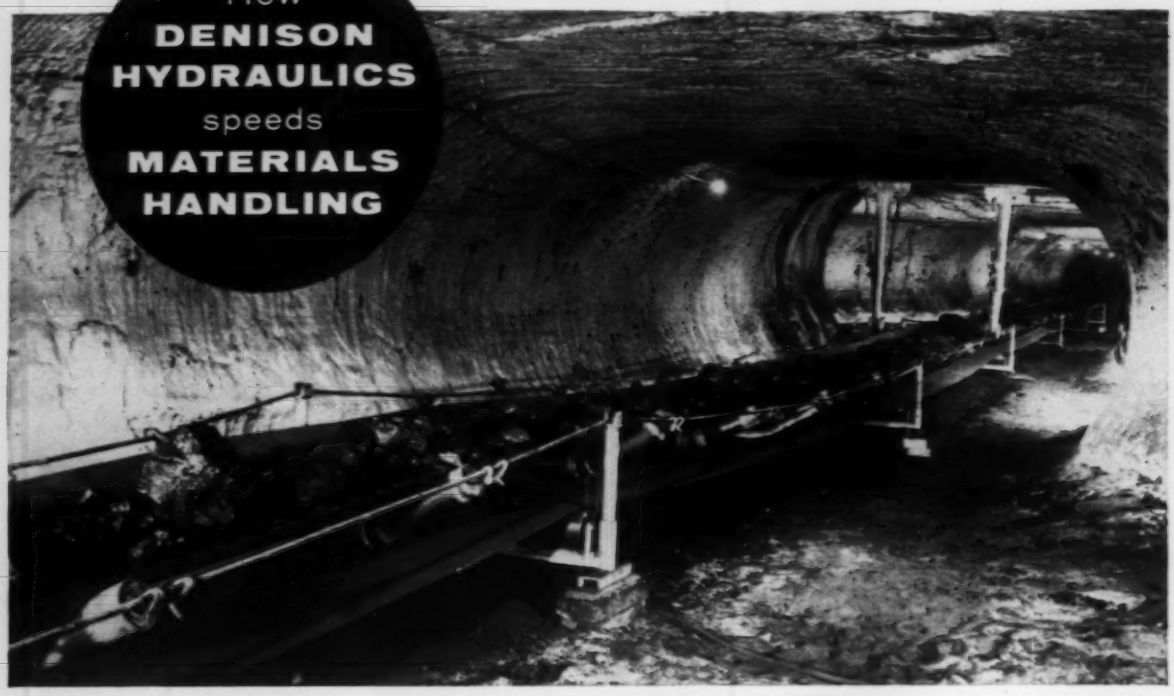
J-30288

YOU CAN BE SURE...IF IT'S Westinghouse

Circle 431 on Page 19

How **DENISON HYDRAULICS** speeds **MATERIALS HANDLING**

BELT-LOADS OF COAL FLOW SMOOTHLY *on Goodman "Ropex" conveyor applying new design concept which supports loaded belt on chain-linked suspended idlers. Denison hydraulic power drives the "Ropex" efficiently at low cost.*



Here's how the **GOODMAN** "Ropex" conveyor rolls vibration-free on **DENISON** hydraulic power

Faced with the problem of designing drives and controls for coal mining machines that would give smooth, flexible, vibration-free power—Goodman Manufacturing Company found the answer . . . a Denison hydraulic transmission system.

In developing the "Ropex"—an extensible belt-supported conveyor—Goodman designers incorporated four rugged Denison Axial Piston Pumps, four Fluid Motors and relief valves.

"ROPEX" SELF-PROPELLED CONVEYOR *developed by Goodman Manufacturing Co., Chicago, incorporates 4 Denison Axial Piston Pumps, 4 Fluid Motors and relief valves in its smooth, hydraulic transmission. Shown above, "Ropex" tail section with position of Denison hydraulic motor and valves indicated.*

The "Ropex" consists of two basic sections: The *head end section* discharges on the secondary belt and holds 100 feet of belt storage . . . paying in and out as the tail end moves. The *tail end section* stores 650 feet of wire rope (which supports belt rollers) on each rope drum. Ropes are kept tight, when winding or unwinding, by two hydraulic motors.

In the tail end, two Denison Fluid Motors operate the tractor treads—and are controlled by two Denison Pumps for low-speed tramming or moving backward and forward. Two other Denison Fluid Motors independently drive gearing of the rope drums. For high-speed moving from place to place, the two pumps which furnish power for the ropes are diverted to supply power for the treads.

Result: a compact "Ropex" unit that cuts moving costs . . . increases load-carrying ability with minimum spillage . . . assures continuous trouble-free operation . . . ease of control.

It's another efficient job done by Denison hydraulic power—the kind of job your Denison hydraulic specialist can help *you* do. Write Denison Engineering Division, American Brake Shoe Co., 1240 Dublin Road, Columbus 16, Ohio.

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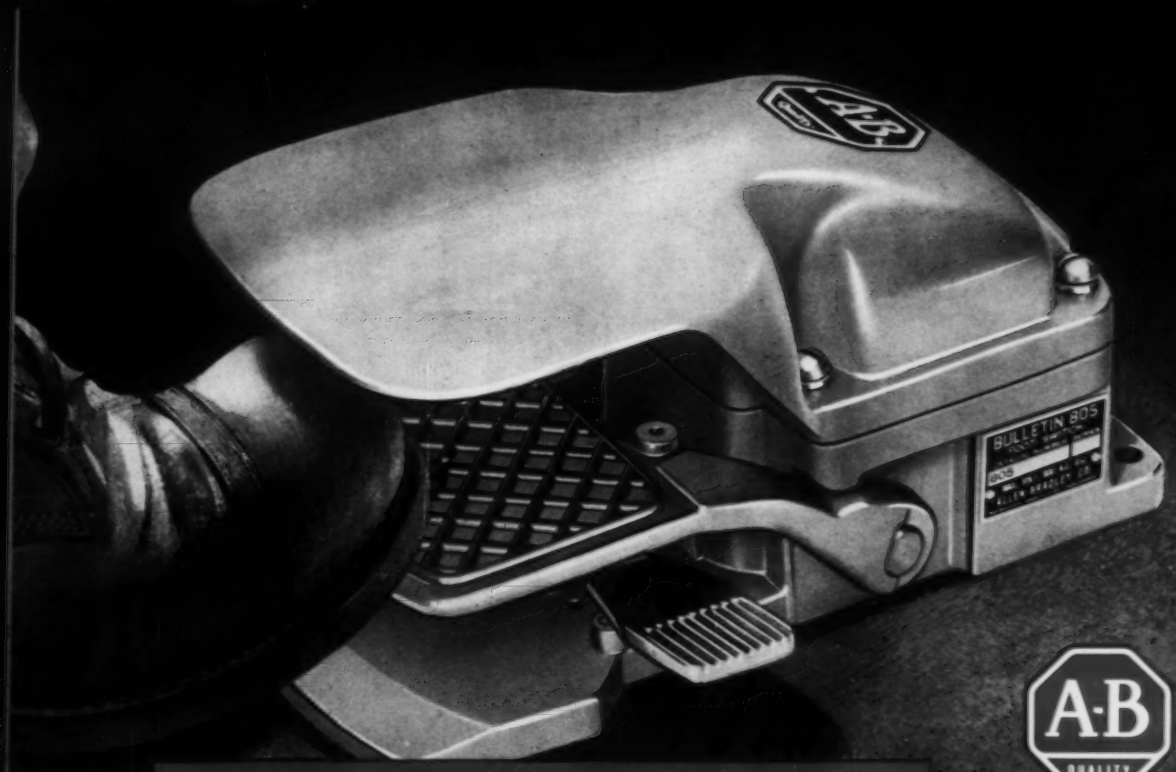
DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Circle 432 on Page 19

Circle 433 on Page 19→



FOOT SWITCHES that can take it!

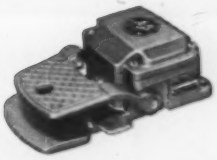
• **BUILT FOR THE TOUGHEST SERVICE** inside and out—from the maintenance free, snap action, double break, silver alloy contacts to the rugged, die cast aluminum housing—the redesigned Allen-Bradley Bulletin 805 foot switch is a challenge to tough jobs! The on-center treadle operation eliminates the need for bolting down the switch—the extended base keeps it from tipping.

• **VERSATILE OPERATION**—The contact trip point is easily adjustable. When equipped with two contact blocks, this foot switch can be set for simultaneous or two-stage operation. The Bulletin 805 foot switch can also be furnished with a latch to provide maintained contact operation. In addition, this latch, when desired, can be made inoperative, and may be quickly changed from one to the other side of the foot switch.

The Bulletin 805 housings are available for NEMA Type 4 watertight and oiltight applications, or NEMA Type 7 explosion-proof service.

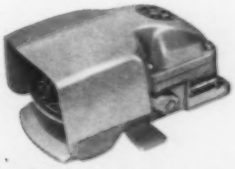
Try the Allen-Bradley Bulletin 805 foot switch—you'll find it "tops" in its field. Send for full information.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.



Bulletin 805 Style A switch with latch.

Bulletin 805 Style A switch with latch and top guard to prevent accidental operation.



Bulletin 805 Style A switch with latch and guard covering both top and sides.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

1-58-MR

Husky

BULLETIN 801

LIMIT SWITCHES

IN A THOUSAND AND ONE TYPES

A-B
QUALITY
Roller lever type in watertight enclosure.
Cutaway view of Bulletin 801 heavy duty limit switch. Note the sturdy construction.
Roller fork type in watertight enclosure.
Lever type for rod or chain operation.
Push type, heavy duty switch.
Center roller, standard duty switch.
Switch with two independently adjustable rollers.
Fork type, snap action switch.

From among the hundreds of Allen-Bradley Bulletin 801 general purpose limit switches, you're sure to find your exact requirements. There are 21 different contact arrangements available, including types with single or multiple poles, N.O. and N.C. contacts, spring return or maintained contacts, with either a slow or snap action mechanism. It will pay you to know this *quality* line of limit switches. If you do not already know this quality line, let's get acquainted. Write for the complete story.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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ALLEN-BRADLEY
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QUALITY

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ANNOUNCING!

VICKERS® New ¼" Temperature and Pressure Compensated FLOW CONTROL VALVE

ANOTHER VICKERS FIRST

FOR OPERATING PRESSURES UP TO 2000 psi

For years the Machine Tool Industry has been asking for a combination Temperature and Pressure Compensated Flow Control Valve to insure CONSTANT FEED RATES. Now for the first time it is available as a production unit at a reasonable price.

Check THESE EXCLUSIVE FEATURES that mean Optimum Tool Life and Better Work Finish:

- **TEMPERATURE COMPENSATED** — Constant feed rates all day long with same throttle setting because throttle automatically compensates for changes in oil temperature. The compensator mechanism is simple in design and durable.
- **PRESSURE COMPENSATED** — Constant feed rate throughout entire cycle because built-in pressure hydrostat automatically compensates for load changes.
- **SINGLE THROTTLE COMPLETE RANGE ADJUSTMENT** — Greater flexibility because valve is adjustable within entire flow range of 5 to 1000 cubic inches per minute.
- **REVERSE FREE FLOW AS STANDARD FEATURE** — A standard feature which permits reverse free flow (up to 1400 cu. in. per min.) from outlet to inlet port by-passing control elements.
- **TAMPER-PROOF ADJUSTMENT** — Retension of original feed rate is assured because a set screw prevents inadvertent throttle movement and a cover over the set screw can be locked in place.
- **INTERCHANGEABLE** — This new valve replaces 12 previous models and it is interchangeable with all of them, also the drain connection is eliminated on the new valve to simplify piping.
- **GREATER ECONOMY** — No need to stock several valves for wide range of flow rates. Drain connection is eliminated, piping costs are reduced.
- **MAXIMUM RELIABILITY AND ACCURACY** — Design of temperature and pressure control components assures maximum circuit reliability and extreme accuracy of feed through a range of 5 to 1000 cubic inches per minute.

FOR ADDITIONAL INFORMATION SEND FOR I-195040 7945

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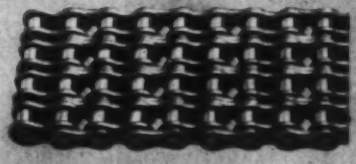
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

A.S.A. ROLLER CHAIN

Complete line of A.S.A. Roller Chain ¼" pitch through 2½" pitch carried in stock. Large back up parts in stock.

HEAVY ROLLER CHAIN

Complete line of Heavy series Roller Chain ¾" pitch through 2½" pitch carried in stock. Large back up parts in stock.



MULTIPLE STRAND CHAIN

Complete line of Multiple Strand Chains ⅜" pitch through 2½" pitch. Single, double, triple or quadruple carried in stock. Any width desired made to order.

EXTENDED PITCH CHAIN
(CONVEYOR SERIES)

Straight side bars 1" pitch through 1½" carried in stock. Large stock of parts ready for assembly and quick delivery.

EXTENDED PITCH
(DRIVE CHAIN)

(Drive Chains figure "8" Sidebar) 1" pitch through 1½" carried in stock. Large stock of parts for quick assembling and delivery.

CABLE OR SLING CHAINS

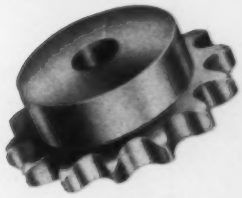
⅜" pitch through 2½" pitch. Any lacing and width required. In stock . . . extra finished parts stocked for assembly and quick delivery.

CORROSIVE RESISTANT CHAIN

Electrolized all sizes and types—in stock ½" pitch through 2½". *Bronze* in stock ½" pitch through 1" pitch. *Stainless* steel in stock ⅜" pitch through 1" pitch. Other pitches to order.

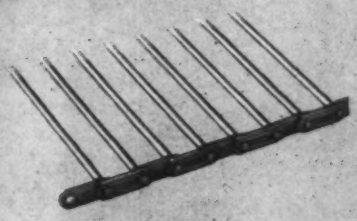
ATTACHMENT CHAIN

Alloy steel, stainless steel, bronze, Electrolized. Single, multiple and extended pitch. Large stock of parts for quick deliveries. Specialty department for service on specials.



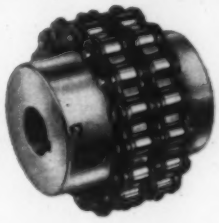
A.S.A. ROLLER CHAIN SPROCKETS

Complete line of A.S.A. Roller Chain Sprockets ⅜" pitch through 2" pitch carried in stock ready for delivery.



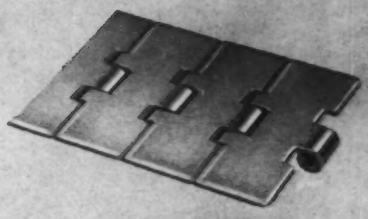
SPECIAL CHAIN

Atlas makes approximately 100 special chains and will make any chain, any pitch required and assure good deliveries.



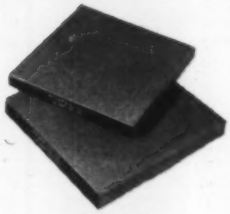
FLEXIBLE COUPLINGS

Complete line of steel chain couplings carried in stock. Stainless steel, bronze and Electrolized are available made to order.



ELECTROLIZED FLAT-VEYOR CHAIN

Chain and sprockets—complete line of both Electrolized and carbon steel carried in stock. Also available in stainless steel upon order.



PACKAGING

Parts and all chain. 10 ft. packages, 100 ft. packages, reels, parts packaging. Efficient, clean, easy to handle.

COMING PRODUCTS

1. Offset Sidebar Chain (early 1958)
2. High Strength High Wear Chain

COMPLETE CATALOG

The Complete ATLAS CHAIN LINE

One of the most complete transmission lines in the industry

You name it . . . Atlas has it . . . the right chain for your power transmission or conveying needs.

Atlas Products are known for their unsurpassed quality . . . pre-tested to give better service under the toughest operating conditions.

Many exclusive features of Atlas Products—such as Electrolized Chain, Sprockets and Couplings and Flat-Veyor Chain—result in outstanding performance. Constant development of new products by Atlas research laboratories—most modern in the field—is your assurance of even better performance in the future.

Atlas Chains are made in all sizes . . . in steel, stainless steel, bronze and the new Atlas Electrolized Chain for service under corrosive conditions.

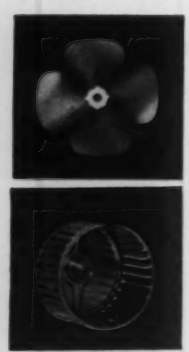
Call or write us or your closest Atlas distributor. Atlas engineers will gladly work with you and recommend the right Atlas Products for your unusual installations.

ATLAS CHAIN & MANUFACTURING COMPANY

WEST PITTSTON, PENNA.

Circle 435 on Page 19

TAILORED FOR YOU TO A "T"



Torrington technology, tools and testing facilities are the finest in the world for tailoring air impellers specifically - and precisely - to your new product requirements.

These three T's of Torrington are the tangible assets of an unmatched experience in equipping the successful products of every major manufacturer in the air moving industry.

And the three T's of Torrington are yours for the solution of any problem relating to the moving of air.

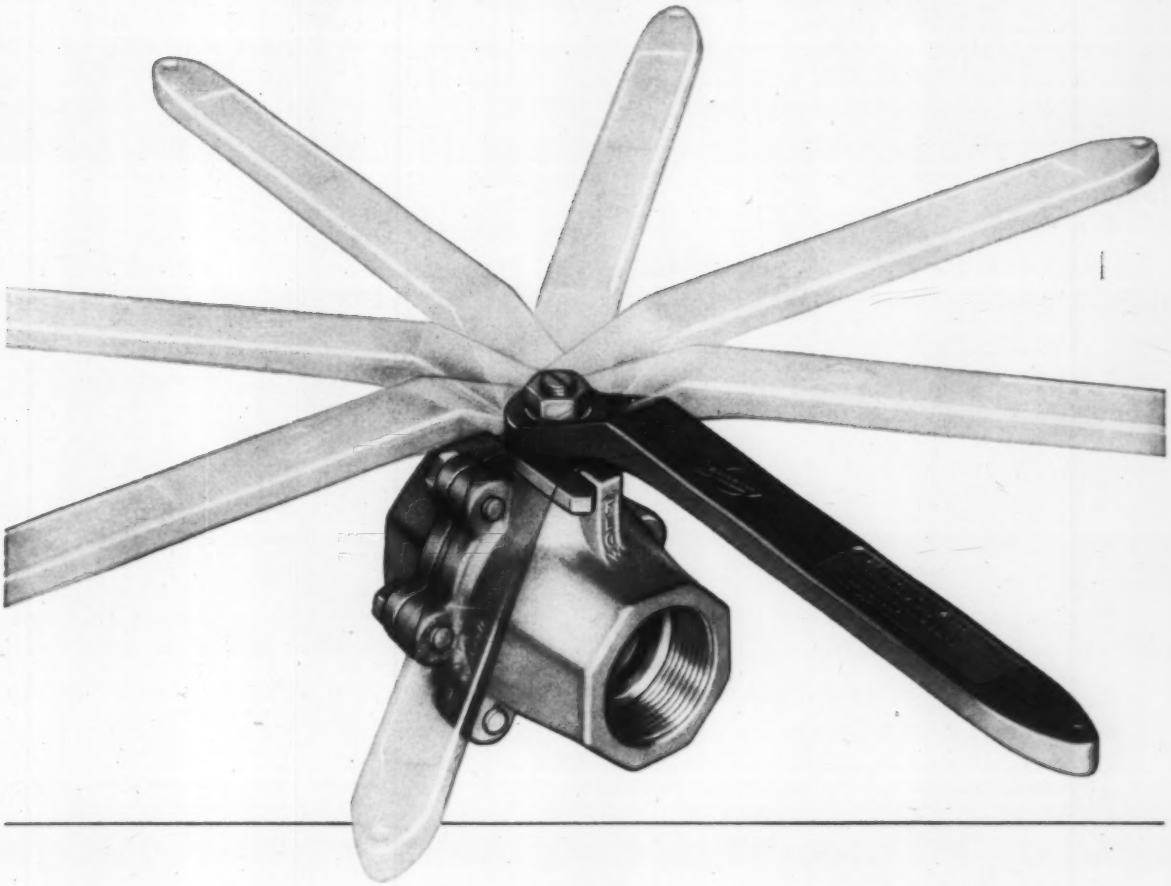
Talk to Torrington!

THE TORRINGTON MANUFACTURING COMPANY

TORRINGTON, CONNECTICUT • VAN NUYS, CALIFORNIA • OAKVILLE, ONTARIO

New Rockwood Forged Ball Valves

8 Ways Easier to Handle!



New Rockwood Ball Valves are made of forged brass for greater tensile strength and safety. You're assured of Full, Round Flow and fast, efficient operation and less friction loss too.

The handle of the new Rockwood Forged Ball Valve can be positioned in 8 different ways *giving you greater convenience.* The ¼ turn opens and closes the valve — *giving you Full, Round Flow, efficient operation, less friction.* The pressure of fluid in the Rockwood Forged Ball Valve automatically positions the ball against the synthetic rubber seat — *giving you a leakproof seal.* The forged brass ball in the Rockwood Forged Valve is chrome-plated to stand up under abrasion, pitting, scratching — *giving you trouble-free service.*

The new Rockwood Forged Ball Valve comes in pipe sizes from ⅜" to 2". Tested and listed by Underwriters' Laboratories, Inc. Mail the coupon now for complete specifications and information.

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
2168 Harlow Street
Worcester 5, Mass.

Send me illustrated folder on Rockwood Full, Round Flow Ball Valves.

Name.....

Title.....

Company.....

Street.....

City.....

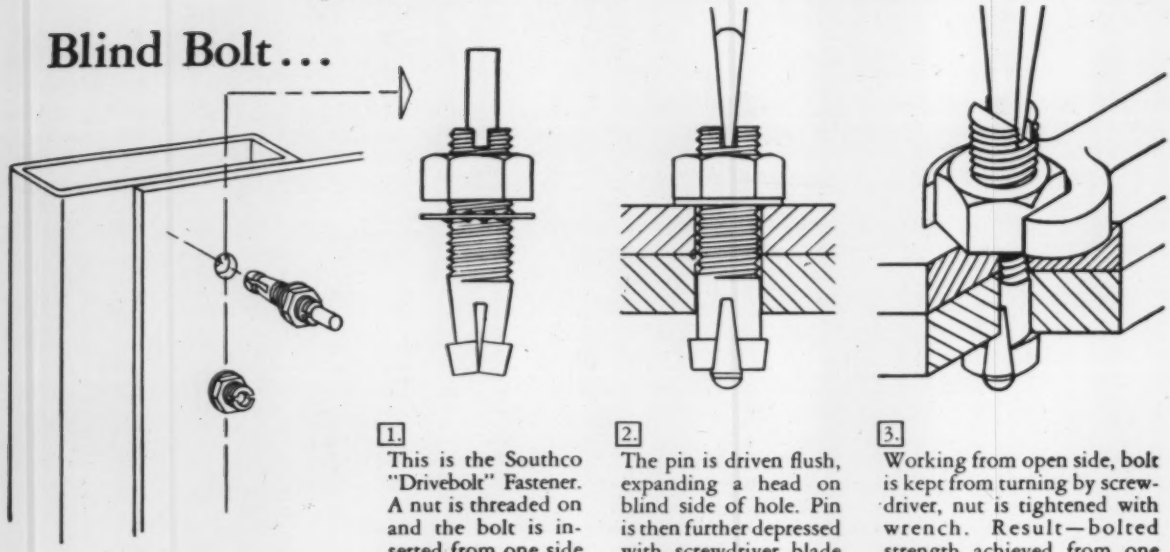
Zone....State.....

Circle 437 on Page 19

Simplified Bolting and Riveting in Blind Applications

For fastener applications accessible only from one side of the work, you can now bolt or rivet without special tools . . .

Blind Bolt . . .

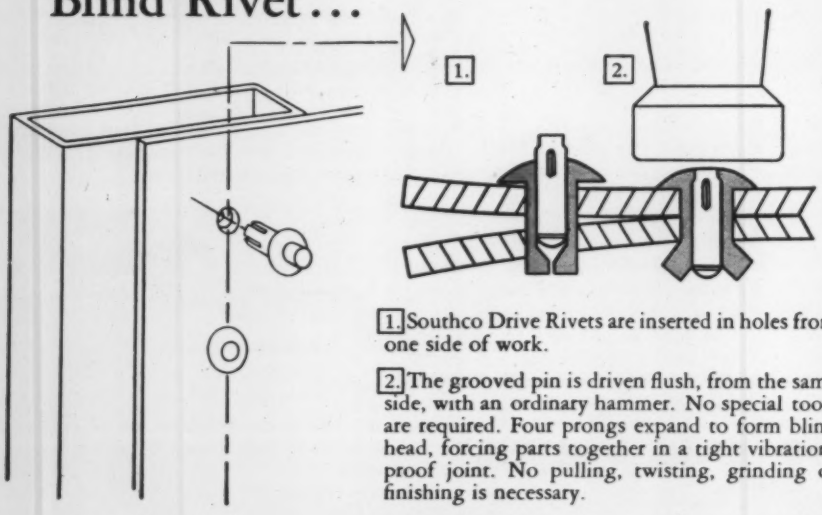


1. This is the Southco "Drivebolt" Fastener. A nut is threaded on and the bolt is inserted from one side of the work.

2. The pin is driven flush, expanding a head on blind side of hole. Pin is then further depressed with screwdriver blade to clear slot.

3. Working from open side, bolt is kept from turning by screwdriver, nut is tightened with wrench. Result—bolted strength achieved from one side of job.

Blind Rivet . . .



1. Southco Drive Rivets are inserted in holes from one side of work.

2. The grooved pin is driven flush, from the same side, with an ordinary hammer. No special tools are required. Four prongs expand to form blind head, forcing parts together in a tight vibration-proof joint. No pulling, twisting, grinding or finishing is necessary.

FREE!

Fastener Handbook

Send for your free copy of Fastener Handbook No. 7, just released. Gives complete engineering data on these and many other special fasteners. Fifty-two pages, in two colors.

Write on your letterhead to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.

SOUTHCO FASTENERS

LION

©1956

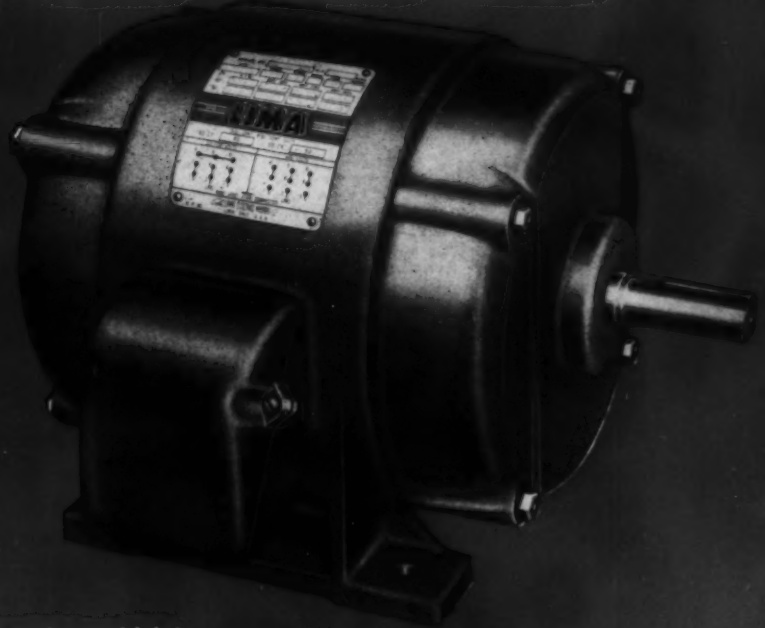
Circle 438 on Page 19

A New Approach to Perfection

MAINTENANCE-FREE LIMA MOTORS

IN ALL NEW NEMA FRAME SIZES

- 30% LESS WEIGHT PER HORSEPOWER
- 30% VOLUMETRIC SIZE REDUCTION
- DUAL FANS INTEGRALLY CAST WITH ROTOR
- COMPLETE ROTOR ASSEMBLIES DYNAMICALLY BALANCED
- RIGID, CAST IRON FRAMES WITH INTEGRALLY CAST FEET
- DIAGONALLY SPLIT CAST ALUMINUM CONNECTION BOXES—CADMIUM PLATED COVER SCREWS
- TOTALLY ENCLOSED FRAMES MEET J.I.C. SPECIFICATIONS



Slash maintenance costs and eliminate costly inspection and lubrication programs with Lima Motors in NEW NEMA frame sizes. With lubricated-for-life DOUBLE-WIDTH ball bearings, solid die cast aluminum rotors with dual integral fans, and Mylar insulation . . . Lima gives you higher full-load speeds with the most complete motor protection available. Install these new Finest Quality Lima Motors—and forget them.

Lima now has in production all ratings in new NEMA frame sizes 182 through 326U. Get complete details on Lima's new NEMA *maintenance-free* motors from your Lima Representative now! If he is not already calling on you, his name and address will be found in *Thomas' Register, MacRae's Blue Book* or *Conover-Mast Purchasing Directory*.

Of course, Lima will continue to produce regular NEMA frame sizes 66 to 505 (⅓ to 150 H.P.), incorporating the latest advances in motor design.

THE OLD WAY

Open and unprotected motor bearings subject to contamination and must be inspected and lubricated frequently.

THE LIMA WAY

Sealed and protected—Lima's DOUBLE-WIDTH pre-lubricated motor bearings require no attention—just put the motor to work and forget it.

THE LIMA ELECTRIC MOTOR CO., INC., 4891 Findlay Road Lima, Ohio

Representatives throughout the U. S., Canada and abroad

FIRST . . . FOR MOTORS . . . DRIVES . . . SPEED REDUCERS

Circle 429 on Page 19

TOOLING FOR COMPETITION

ATTEND THE

1958 ASTE TOOL SHOW AND CONFERENCE

CONVENTION CENTER
PHILADELPHIA, MAY 1-8

SEE all the very latest advancements and improvements in more than thirty major categories of industrial products.

It's the year's most notable industrial event . . . it's your chance to see tooling's future, *your* future on display, at *one* time under *one* roof . . . it's the 1958 *TOOL SHOW!* See for yourself all the newest developments in manufacturing equipment, all the latest ideas in production methods. See thousands of products, hundreds of product demonstrations, presented by 487 exhibitors. Don't miss it. Plan *now* to attend.

ATTEND top level conferences, conducted by recognized authorities on the newest production techniques and developments.

Symposia, panels and technical papers (more than 80 of them) will be devoted to timely subjects of vital interest to today's industry . . . subjects like the following . . . Automation* • Materials of the Future • Numerical Control • Guided Missiles • Plastic Tooling • Nuclear Engineering • Shaped Diamond Tools* • Planning for Profit • Ceramics • Powdered Metal Parts Tooling • European Tool Engineering • Gauging Techniques • Safety Engineering • Metal Cutting* • Shell Molding.

*Symposium

MEET and exchange ideas with management, engineering, production, sales people from the nation's leading industrial concerns.

Industry's "D-men" . . . designers, deciders, doers . . . will be out in strength for the 1958 *TOOL SHOW*. ASTE's Registration Listings, in fact, read like blue ribbon rosters of industrial America. And small wonder! . . . for the ASTE *TOOL SHOW* is industry's greatest open forum for exchanging ideas, solving problems, *"tooling for competition"*. What better opportunity for keeping yourself informed and up-to-date? . . . and what could be more important in these competitive times?

INSPECT the modern equipment and up-to-the-minute manufacturing methods being utilized in booming Delaware Valley plants.

Yes, you'll have an opportunity to see industry in action, too, because arrangements have been made for 28 tours through Philadelphia area plants . . . including the U.S. Navy Yard.

These 14 plants will be open for your inspection . . . Standard Pressed Steel • U.S. Steel • Leeds & Northrup • Chrysler-Plymouth • Cuneo Eastern Press, Inc. • Campbell Soup Co. • I.T.E. Circuit Breaker • Schramm, Inc. • Yale & Towne • Budd Company • Brown Instrument • Link-Belt • Fischer & Porter • Curtis Publishing.

SEND FOR YOUR ADVANCE REGISTRATION MATERIALS TODAY!

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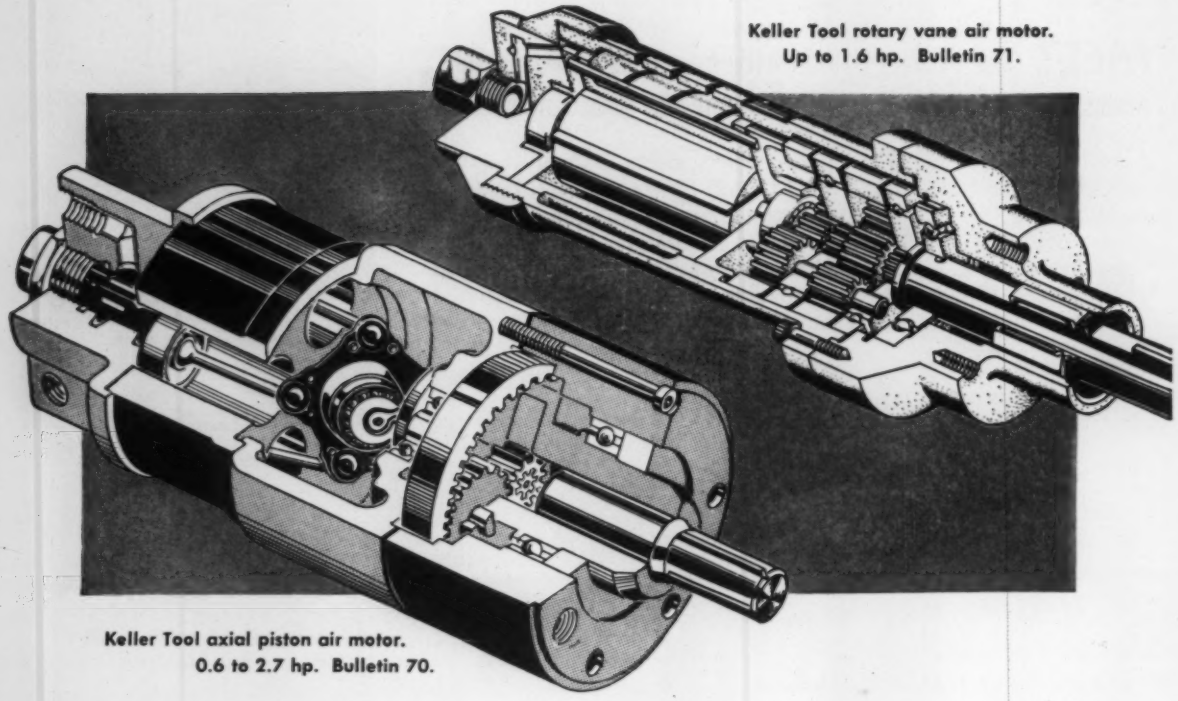
AMERICAN SOCIETY OF TOOL ENGINEERS

TOOL SHOW CONFERENCE '58 MAY 1 TO 8

Circle 440 on Page 19



Keller Tool rotary vane air motor.
Up to 1.6 hp. Bulletin 71.

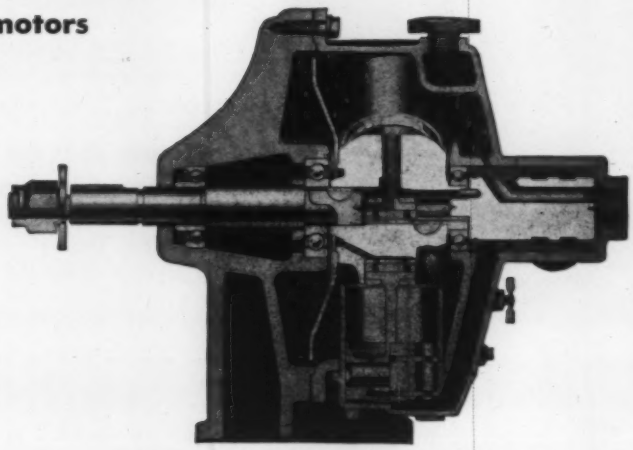
Keller Tool axial piston air motor.
0.6 to 2.7 hp. Bulletin 70.

Air power is idea power . . .

when your design calls for motors with these features:

High starting torque
Reversibility without power loss
Variable speed, easily controlled
Cool operation
Instantaneous starts and stops
Consistent torque output
Non-sparking characteristics
Thrust and axial spindle loads
Enclosed construction
Output from ½ to 16 hp.

AIR MOTORS are your answer
Write for detailed bulletins.



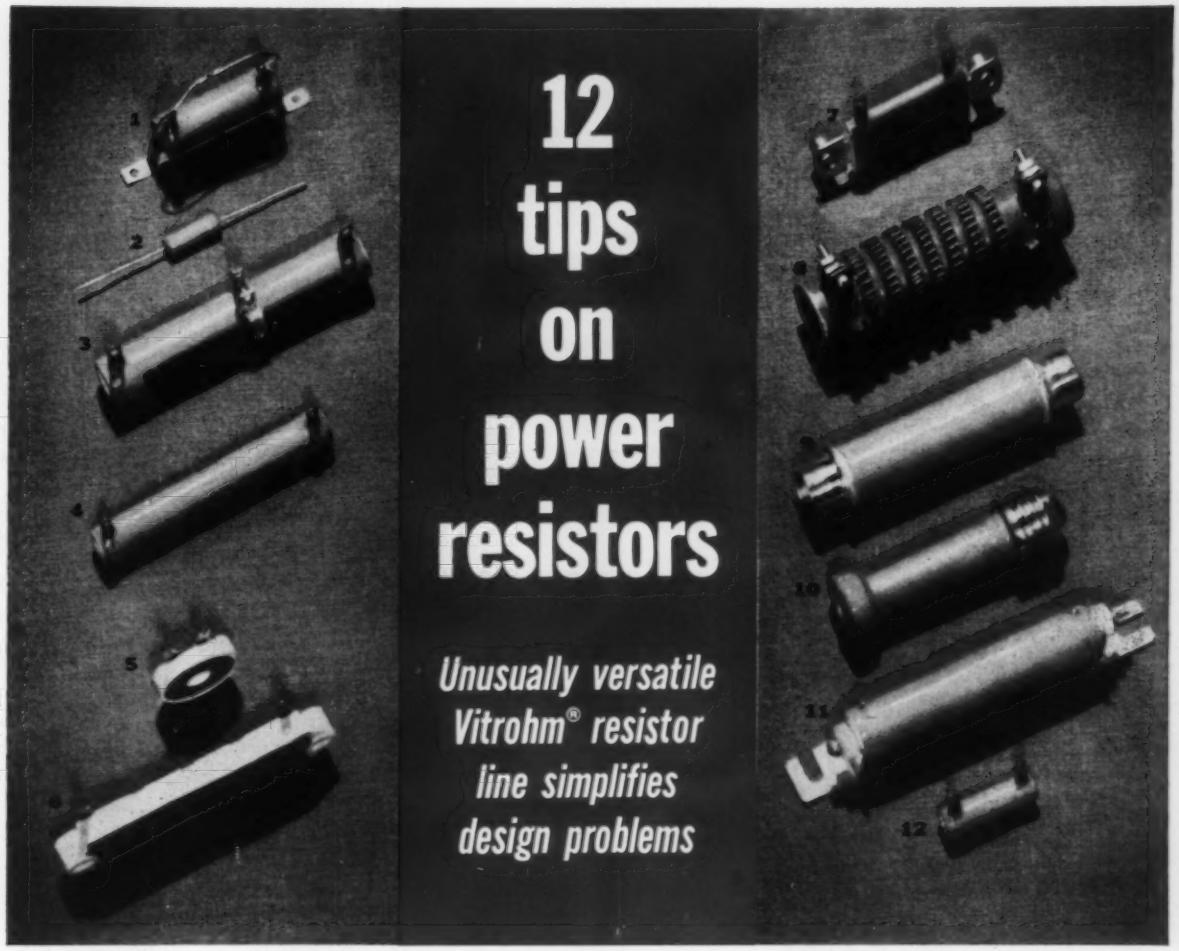
Gardner-Denver five-cylinder radial
air motor. 3 to 16 hp. Bulletin AM-1.

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER - DENVER

Gardner-Denver Company, Quincy, Illinois

Circle 441 on Page 19



Did you know that high reliability Vitrohm Resistors can take on almost every shape the designer needs? More than 11 styles fit almost every design requirement. All have the same outstanding Ward Leonard quality—quality that protects *your* reputation as an equipment designer. For example:

1 FIXED Vitrohm tubulars come in 5-to-200 watt sizes. **2** AXIOHM, standard in 3, 5, or 10 watts, with axial leads is ideal for compact electronic gear. **3** ADJUSTOHMS make it easy to get the right voltage, bleeder or bias current.

4 NON-INDUCTIVE Vitrohm tubulars, up to 160 watts in stock sizes. Famous flatted sides and 'Ayrton-Perry' winding keeps down inductance and capacitance. **5** DISC-OHMS, at 24 watts, feature extra compact mounting and **6** PLAQOHMS, sizes to 150 watts, are also non-inductive. **7** STRIPOHMS, from 20 to 75 watts, are another way to save space—an easy, compact way to stack mount resistors. **8** RIBFLEX resistors (made to order) can dissipate up to 550 watts and take terrific momentary overloads. Resistances from 0.04 to 66 ohms.

9 FERRULE TERMINAL resistors (made to order) feature fuse-clip-type mounting. **10** SCREW BASE resistors (also made to order) are suited to equipment requiring ready change of resistance values. **11** BRACKET TERMINAL resistors have leads silver-brazed to mounting brackets. Mounting the resistor completes electrical circuit.

12 MIL-R-26C Vitrohm Resistors available in all styles—all sizes—all characteristics and all resistance values listed in the specification.

Designing with power resistors is easy with the 64-page Ward Leonard Catalog 15. It's full of data on these resistors and more. Write for your copy today. Ward Leonard Electric Co., 58 South Street, Mount Vernon, N. Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.)

8.1

LIVE BETTER...*Electrically*

WARD LEONARD ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

Result-Engineered Controls Since 1892

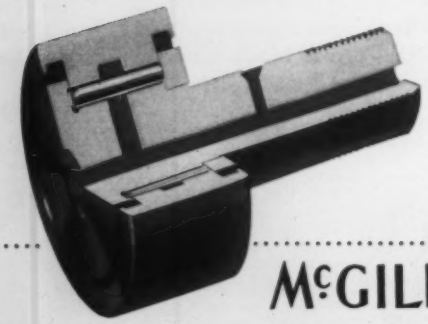
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

For BETTER CONTROL of FLUIDS...

Specify Norgren CONTROL VALVES

DIAPHRAGM TYPE VALVES

Automatically protect against damage from excessive pressure build-up. Provide controlled operation for fluid recirculating systems.

Easily adjusted to relieve at desired pressure. Relief settings: 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi, 0-250 psi for pipe sizes ⅛" through ½", and 0-15 psi, 0-50 psi, 0-75 psi, 0-125 psi for ¾" and 1" pipe sizes.

POP SAFETY VALVES

Prevent the build-up of dangerous, excessive pressures in air tanks. Valve automatically pops open at desired setting. Pipe sizes ⅛", ¼", ⅜" and ½".

LOW FLOW RELIEF VALVES

Small, inexpensive valves suited for a wide variety of uses requiring relief at low rates of flow. ⅛" and ¼" pipe sizes.

FLOW CONTROL VALVES,

Two-Way—Single-Way

For accurate control of air and hydraulic cylinders. Provide large volume flow with low pressure drop, easily and quickly regulated. ¼", ⅜" and ½" pipe sizes.

NEEDLE VALVES

Tapered needle provides controlled metering of air, liquids and gases that do not affect brass. Leak-proof. Choice of five types in ⅛" and ¼" pipe sizes.

For complete information, call your nearby Norgren Representative listed in your telephone directory... or

WRITE THE FACTORY FOR NO. 800 CATALOG

C. A. NORGREN CO.

Wherever Air is Used in Industry

3442 SO. ELATI STREET • ENGLEWOOD, COLORADO

Circle 444 on Page 19

Note—Commercial and Military Packaging Engineers:

LINK-LOCK

...is the rugged answer to your exacting container closure problems

LINK-LOCK plays an important role in the design of this container

Simmons' LINK-LOCK provides pressure-tight, impact-resistant closure, plus quick closing and opening, on this reinforced fibrous plastic product made by the new automatic pre-form process developed by Pressurform Container Corp. The two-section container will be used by the Light Military Electronic Equipment Dept. of General Electric Company for shipping airborne radar jamming units to the Air Force.

Of prime importance are the container's lightness, strength, rust- and mildew-resistance, ability to withstand high pressures without distortion, ease of locking and opening, and low cost.

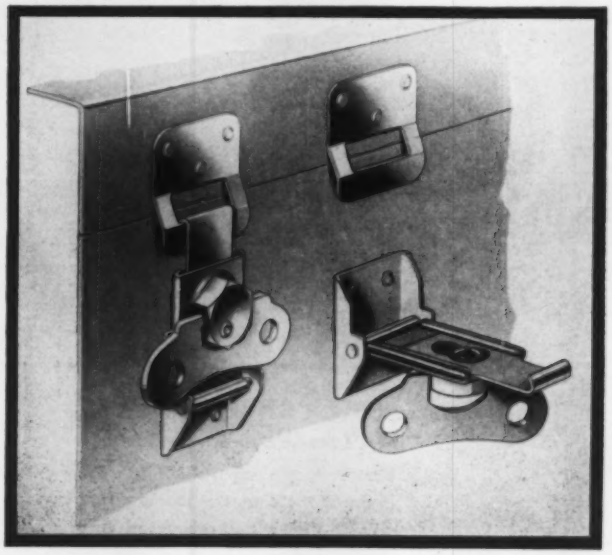
Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Impact and shock resistant (positive-locking).
- Compact design... lays flat against case even when unlocked.
- Available in 3 sizes, for heavy, medium, and light duty.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design... can be varied to suit different conditions.

Also available! Spring-Loaded LINK-LOCK... ideal for less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

Where does the versatile Simmons LINK-LOCK belong in your design? For full information and specifications, send for LINK-LOCK DATA SHEETS today. Samples and engineering service available upon request.

Courtesy of Pressurform Container Corp., and the LMEE Dept. of General Electric Co.



SIMMONS
FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

QUICK-LOCK SPRING-LOCK ROTO-LOCK LINK-LOCK DUAL-LOCK

See our 8-page Catalog In Sweet's 1958 Product Design File

Circle 445 on Page 19

NEW REFERENCE MANUAL

... to help you choose dependable high-speed gear units

Here is one of the handiest manuals on high-speed gear units ever offered. It covers both speed-increasing and speed-reducing units.

Every one of its 28 pages is designed to help you in the efficient selection and application of Farrel SI units. Concise yet complete, the booklet makes it easy for you to choose the proper unit for long service life and trouble-free operation. Diagrams illustrate twelve alternative lubrication systems designed to meet individual requirements.

For your free copy, just fill out the coupon and mail it today.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONNECTICUT

Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, Boston, Akron, Ann Arbor (Mich.), Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston
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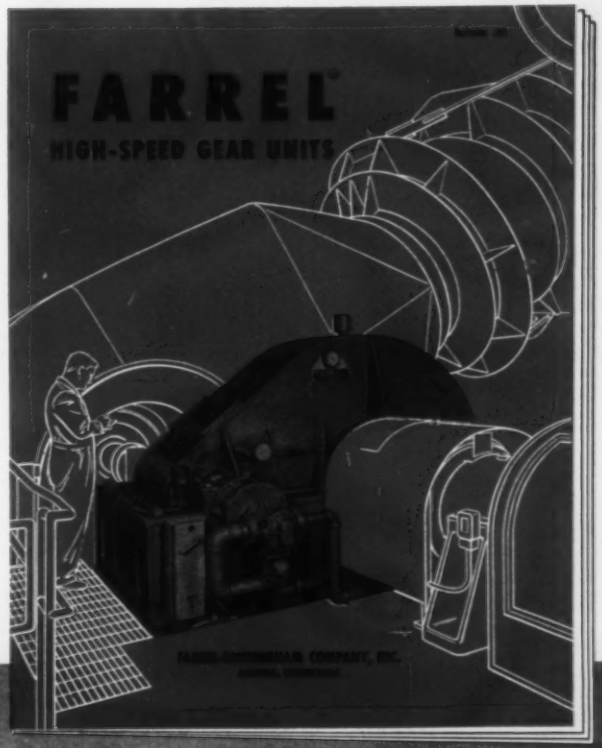

What the booklet contains:

- Description of the units
- General specifications
- Instructions for selecting a unit
- Selection examples
- Table of ratio factors
- Service factor table
- Table of horsepower ratings
- Ordering instructions
- Dimension drawings
- Alternate lubrication systems
- Illustrations and descriptions of eight special test-stand units
- Installation photographs
- Details of other Farrel gears and gear units

Farrel-Birmingham®

FB-1128

Engineers will find this factual manual useful in the selection of drives for a variety of applications. Send the coupon for your free copy.

FARREL-BIRMINGHAM COMPANY, INC., Ansonia, Conn.

Please send me a copy of Bulletin 451, "FARREL HIGH-SPEED GEAR UNITS."

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Company .....

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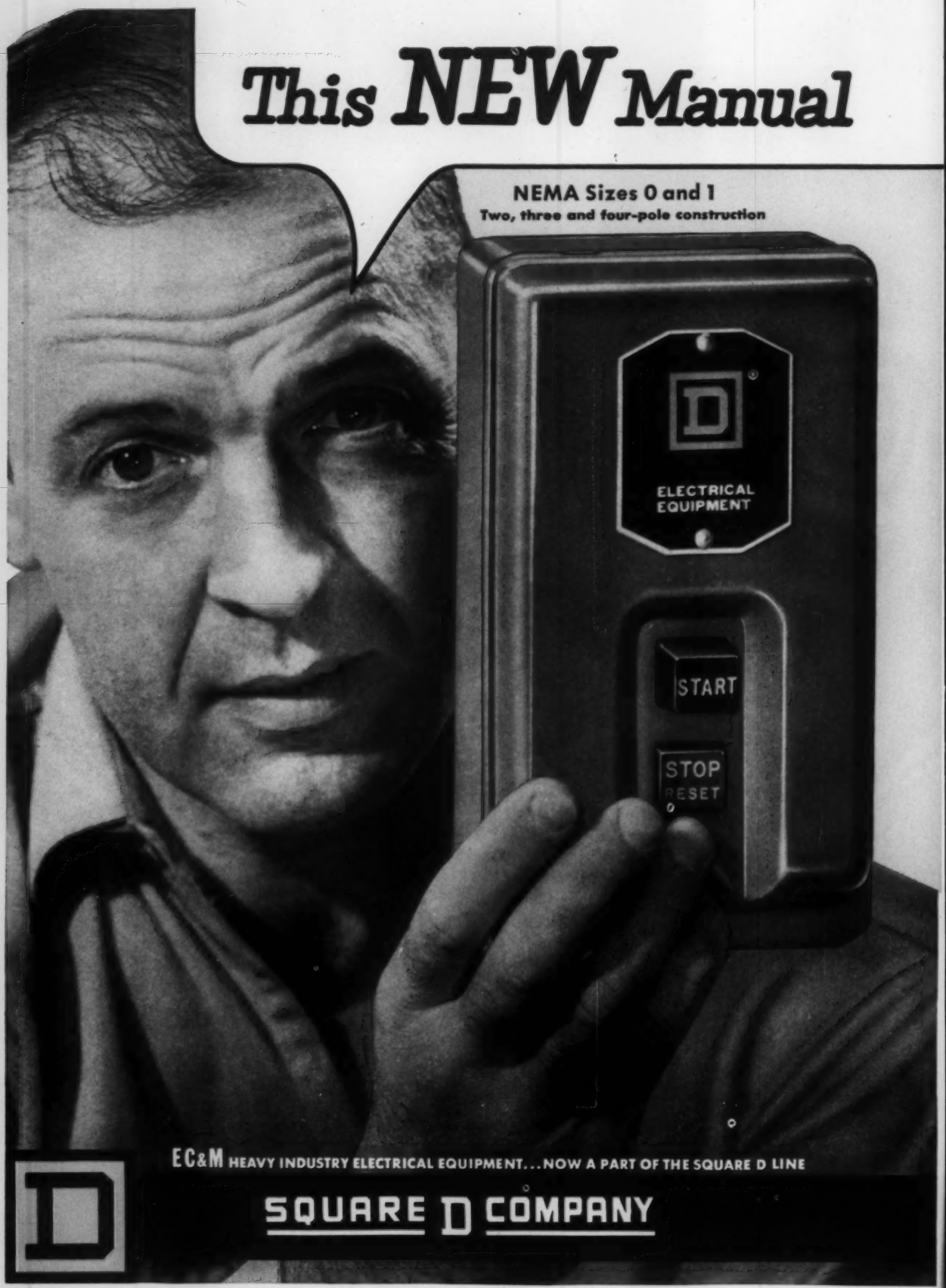
City ..... *State* .....

Circle 446 on Page 19

This NEW Manual



EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

Starter has EVERYTHING!

SMALLER!
Takes less space, whether it's built into machine or mounted externally

SMART STYLING!
Matches the streamlined appearance of today's modern machines

QWIK-MAKE, QWIK-BREAK!
Positive snap action opening and closing of contacts. Longer contact life

TRIP-FREE OVERLOAD PROTECTION!
Impossible for operator to hold motor circuit closed against overload

LONGER LIFE!
Toggle Action operating mechanism. Heavy duty construction throughout

EASIER INSTALLATION!
Wire it without removing starter from enclosure. All terminals have pressure wire connectors

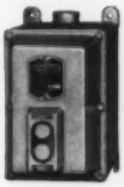
EASIER MAINTENANCE!
"Off-the-Shelf" parts kits make normal maintenance and modifications easier than ever. They're easy to buy, easy to identify, and faster to install

TAMPER-PROOF!
Cover padlocking device prevents tampering by unauthorized personnel. Safety latch locks "start" button in "OFF" position

VISIBLE INDICATION OF OVERLOAD!
Self-centering pushbuttons show when overload has occurred

CHOICE OF ENCLOSURES

Water and Dust-Tight


Hazardous Locations

Flush Mounting

Fractional-horsepower manual starters are available in a full line of enclosures including General Purpose, Flush Mounting, Water and Dust Tight, and Explosion Proof

Write for BULLETIN 2510 B-C

Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

6 SPEED NUTS® replace 10 fasteners ...and costs drop 80%!

Six Tinnerman SPEED NUTS replaced 10 weld nuts on the Gibson Window Air Conditioner... and production costs dropped more than 20 cents per unit!

Working with the designers at Gibson Refrigerator Company, Division of Hupp Corporation, Tinnerman engineers suggested using four "J" Type SPEED NUTS to fasten the front panel to the air conditioner cabinet. These one-piece, self-locking, spring-steel fasteners snap in place by hand; are self-retained in screw-receiving position. They also used two Flat Type SPEED NUTS to fasten the window mounting channel to the cabinet.

By eliminating ten weld nuts, Gibson was able to divert a spot welding machine to other uses, reduce materials handling, simplify and speed up assembly. They cut costs right down the line — without sacrifice of product quality!

Savings like this are being made every day when manufacturers switch from ordinary fasteners to Tinnerman SPEED NUT Brand Fasteners. Over 9000 variations are available to handle practically any fastening job, from tiny transistors to huge freight cars.

Send for complete data on how you can make important assembly-cost savings. And investigate the possibilities of having a Tinnerman Fastening Analysis made of your products. Call your Tinnerman representative, or write to:

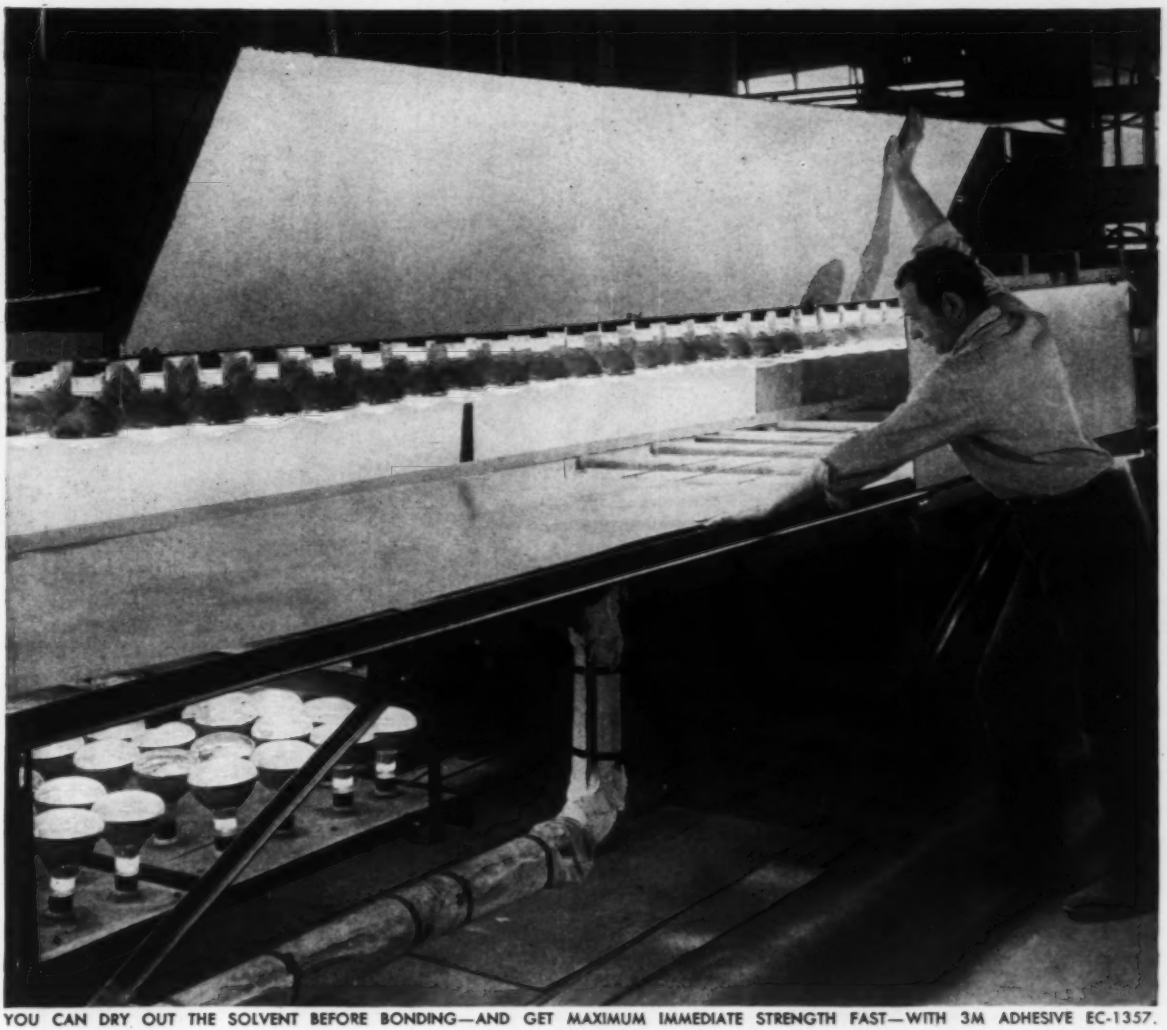
TINNERMAN PRODUCTS, INC.
DEPT. 12 • P.O. BOX 6688 • CLEVELAND 1, OHIO

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hascao-Bundy GmbH, Heidelberg.

Speed high-strength sandwich bonding by predrying 3M adhesive EC-1357



YOU CAN DRY OUT THE SOLVENT BEFORE BONDING—AND GET MAXIMUM IMMEDIATE STRENGTH FAST—WITH 3M ADHESIVE EC-1357.

Here's new speed in making light, rugged sandwich panels for non-load-bearing uses!

It's EC-1357. This specially formulated, fast adhesive from the laboratories of 3M gives you high bond strength *immediately!* With infrared ovens, you can dry the solvent out of EC-1357 before bonding. Heat absorption is fast, due to EC-1357's dark color. You eliminate unnecessary drying and storage time.

You need no clamps or heated presses, just cold press or nip roller. What's more, this cold bond continues to cure at room temperatures—gains added strength with age.

On metal or paper honeycomb cores, EC-1357 builds up a fillet for bigger bonding area and strength. Use EC-1357 with glass foam cores, too.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research, contact your 3M Field Engineer or write on your company letterhead for information and free literature to: 3M, Dept. C-1, 417 Piquette Ave., Detroit 2, Mich.

PRODUCT OF 3M COMPANY RESEARCH

MINNESOTA MINING AND MANUFACTURING COMPANY · ADHESIVES AND COATINGS DIVISION

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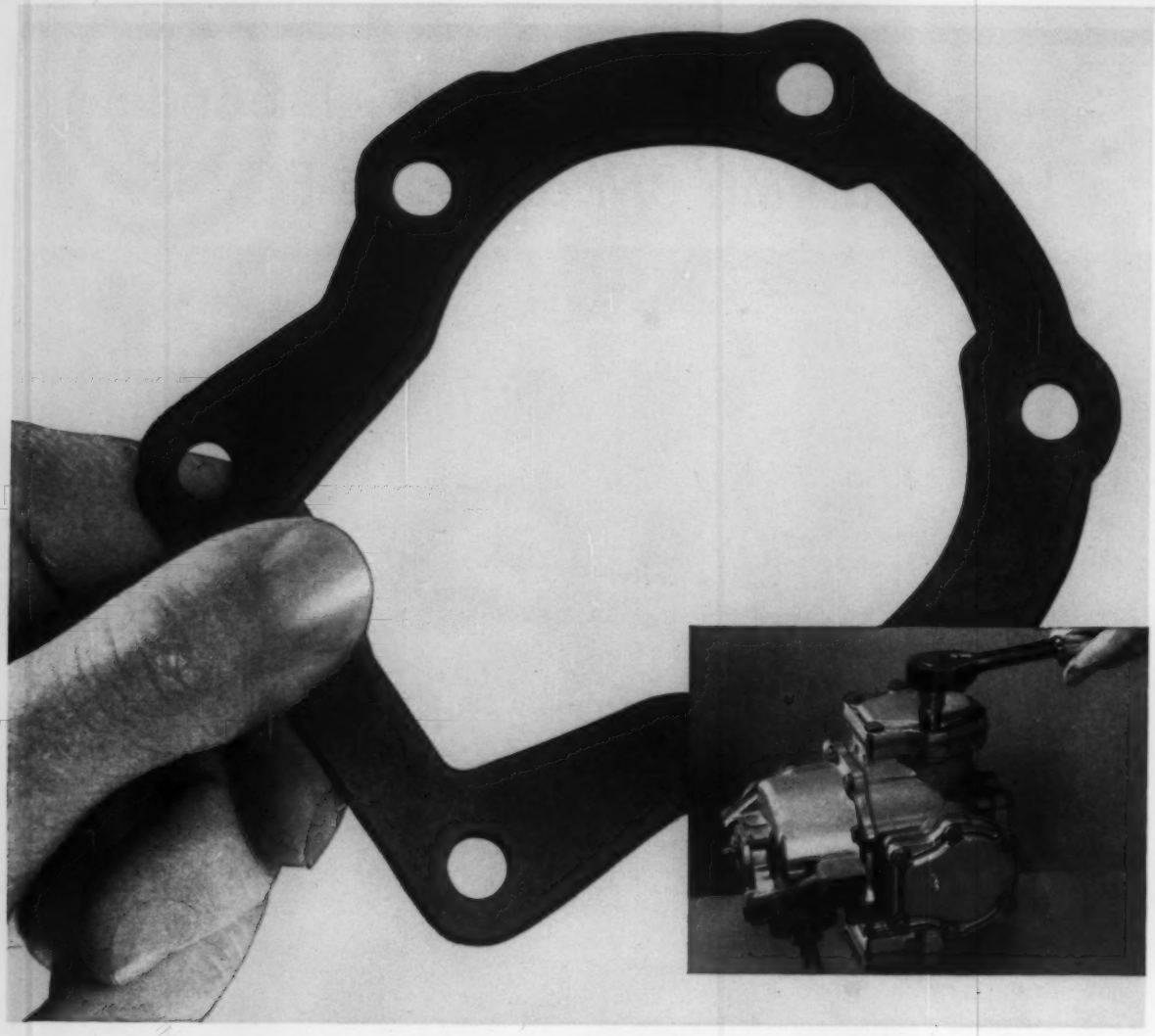
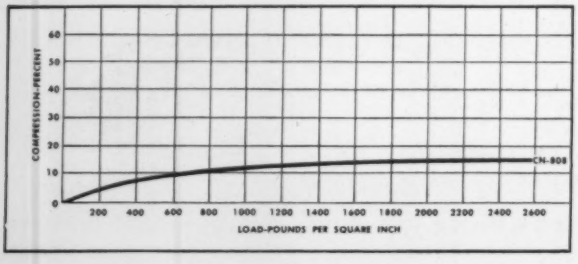


Pre-compressed fiber gasket seals lightweight castings at low flange pressure

Armstrong Accopac® CN-808 is particularly recommended for sealing lightweight flanges, such as the light casting used in this gasoline pump metering unit.

With CN-808, there is no danger of flange distortion. You get an effective seal at bolting pressures lower than with any other fiber gasket material—as low as 800 psi. That's because CN-808 is a pre-compressed material.



Very little of the bolt torque is used to close the interstices normally found in fiber sheets.

CN-808 is made by the patented Armstrong beater-saturation process, in which cellulose fibers and finely ground cork are combined with a non-volatile latex binder. As a result, it has great crush resistance, plus excellent dimensional stability. The special nitrile-type (Buna-N) binder makes CN-808 suitable for sealing gasoline, light petroleum distillates, or water services.

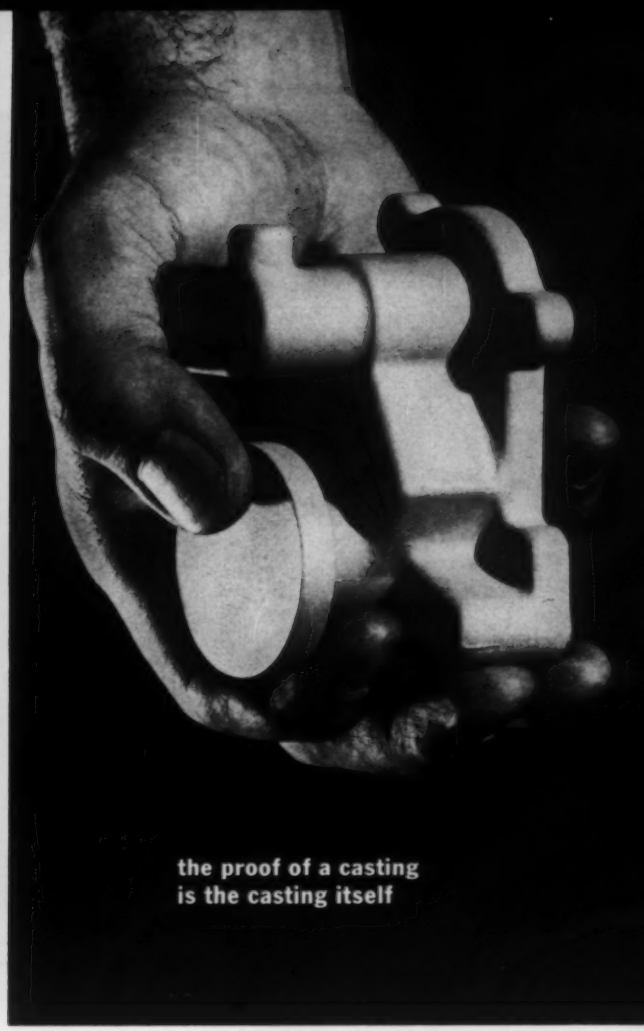
For more information on Accopac materials, write Armstrong Cork Company, Industrial Division, 7001 Dean Street, Lancaster, Pennsylvania.

Armstrong ACCOPAC

. . . used wherever performance counts

Circle 450 on Page 19

the proof of a metal
is a cast test bar



the proof of a casting
is the casting itself

NEW ARWOOD PROCESS NOW GUARANTEES PROPERTIES IN THE CASTINGS THEMSELVES!

Arwood's new process produces aluminum castings that exceed "Aircraft Quality"... Arwood guarantees 37% greater tensile strength... 52% greater yield strength... a three-fold improvement in elongation... based on specimens cut from the casting!

Arwood engineers have perfected an entirely new process of investment casting—the "Suparcast" process that makes it possible for us to *guarantee* mechanical properties that are well above "Aircraft Quality". In critically stressed areas these guarantees can be raised even higher.

It's easy to understand how this new process can help designers shuck off the historical limitations of aluminum investment castings. Now investment castings can be made smaller because they're stronger. Now they can be made lighter. Designers can work in *thick* sections because the new process is especially effective in these areas. And parts can be designed for structural applications because, for the first time, here is a high-strength aluminum investment casting with a measure of ductility.

And here is a practical consideration: If you are now using 356-T6 alloy castings, you can switch over to castings made by Arwood's new "Suparcast" process *without the need to change specifications.*

Write, wire or phone for details.

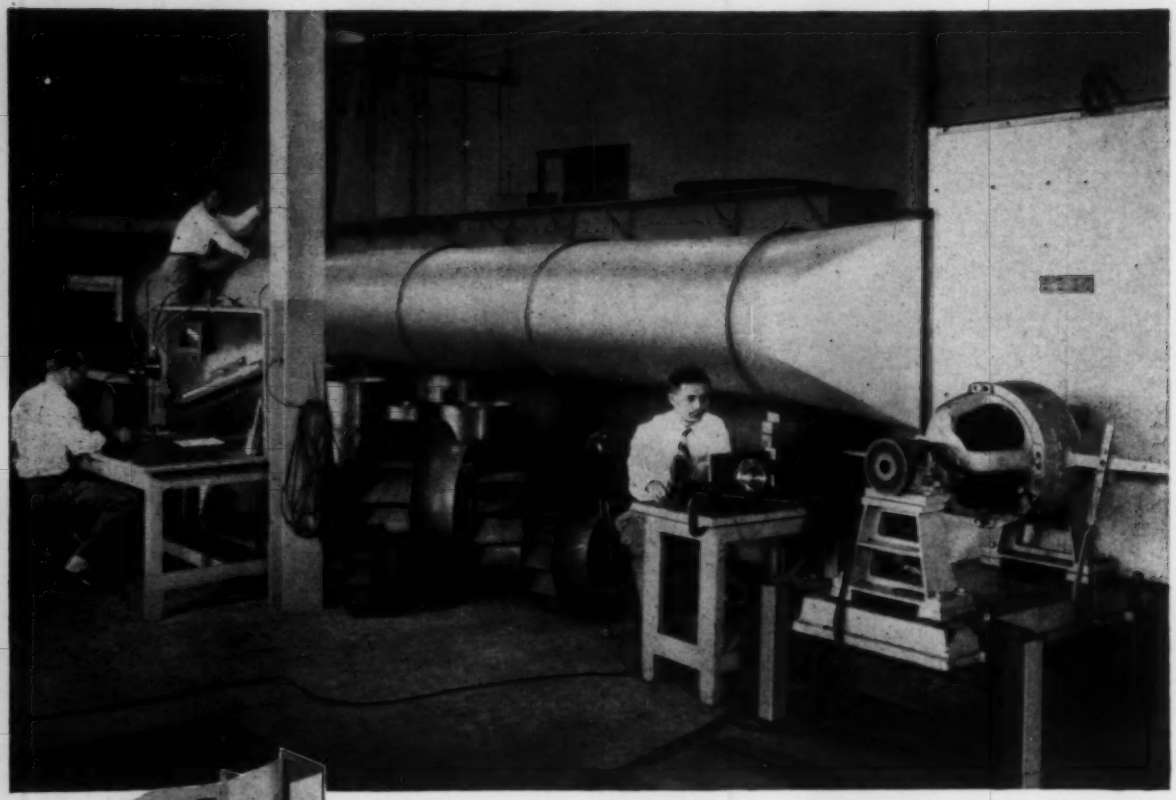
arwood

ARWOOD PRECISION CASTING CORP.
315 West 44th Street, New York 36, New York

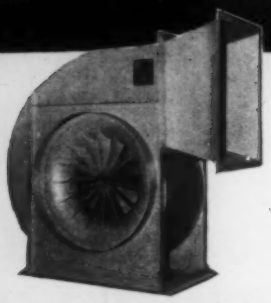
A complete service from design through tooling, production and finish machining. Sixty-two engineering consultants from coast to coast.

PLANTS IN BROOKLYN, N.Y.; GROTON, CONN.; TILTON, N. H.; LOS ANGELES & N. HOLLYWOOD, CALIF.

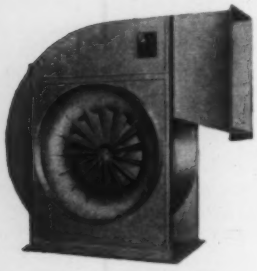
Circle 451 on Page 19



Complete Test Setup at "Buffalo" to Check Fan Wheel Performance Over Entire Range of Operation.



92% Mechanical Efficiency — attained by the "Buffalo" Airfoil Fan.



"Buffalo" Type BLH Fan for Classes II-IV air handling.

WE PAY THEM NOT TO BE SATISFIED —SO THAT YOU WILL BE!

Fan designing and testing at "Buffalo" are jobs that are never "completed" — because once an improved model tests out, our engineers go back to work on a better one!

That's the spirit of dissatisfaction which developed the series of "Buffalo" Airfoil and Semi-Airfoil Fans with choice of wheels to match widely varying requirements — the Types BL and BLH Fans to cover all pressure classifications. And though these fans have set new records for efficiency and stable performance, the work still goes on toward even higher goals. Meanwhile, you get the benefits: the best of hundreds of tested fan designs — the most complete selection of fans for the exact performance you require — the *"Q" Factor or built-in Quality which provides trouble-free satisfaction and long life.*

Write for Bulletins F-200 and FD-106. See why "Buffalo" means a better fan buy.

BUFFALO FORGE COMPANY
BUFFALO, N. Y.

"Buffalo"

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING AIR CLEANING AIR TEMPERING INDUCED DRAFT EXHAUSTING FORCED DRAFT COOLING HEATING PRESSURE BLOWING

SKF

BEARINGS FIT INTO YOUR PLANS

You'll find that high quality SKF anti-friction bearings fit readily into any design. SKF makes a complete line of the four basic types, in over 3,000 sizes, ranging from the smallest to the largest—your best assurance of receiving unbiased advice from experienced SKF engineers. Plan now to simplify the problem of selecting the right bearing for your application. Just call the nearest SKF district office today.

7808

SKF

EVERY TYPE—EVERY USE

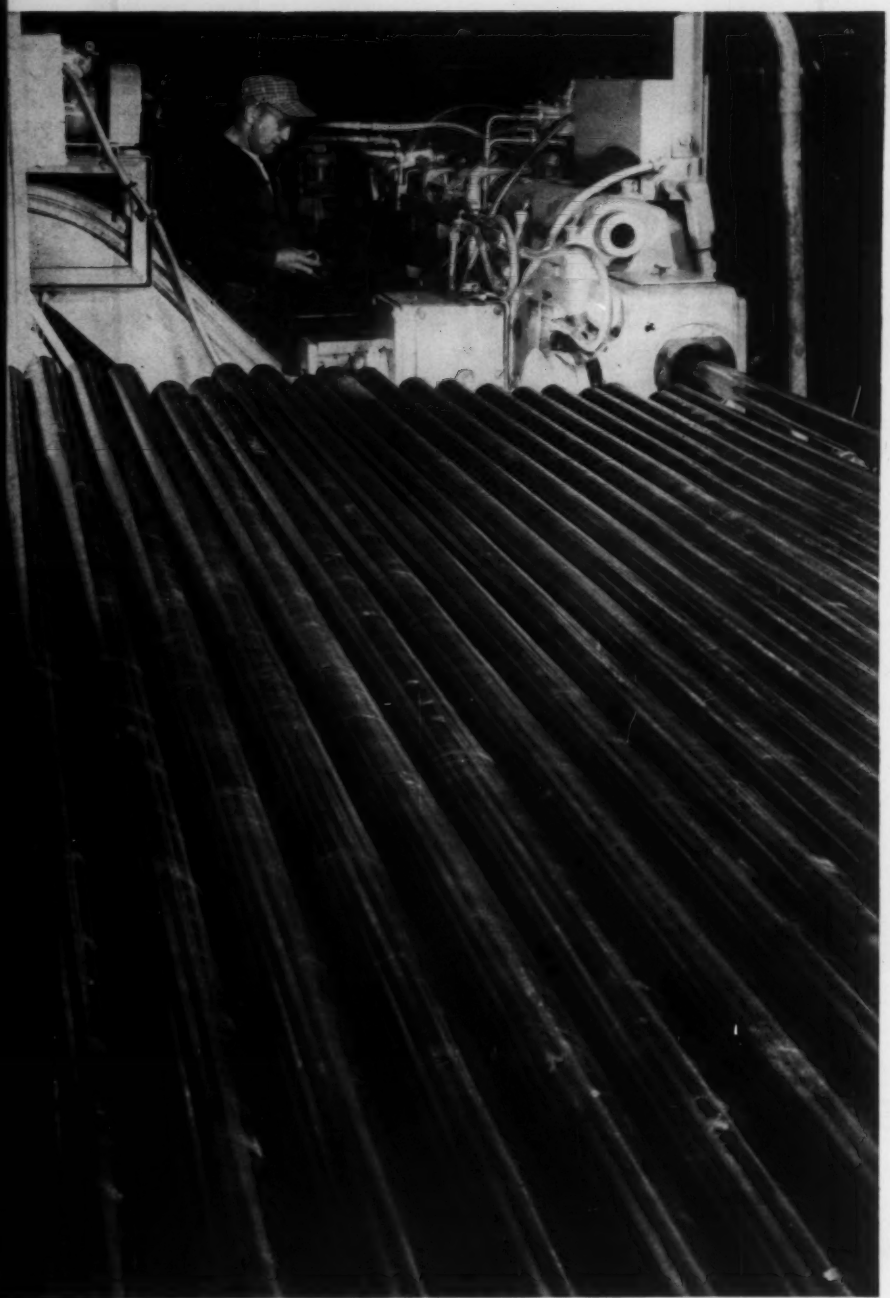
Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

"Reg. U.S. Pat. Off.

SKF INDUSTRIES, INC. PHILADELPHIA 32, PA.

Circle 453 on Page 19

Brand New Transmission in 1958 Cars Uses Pittsburgh Steel Tubes For 3 Key Parts



Here's the raw material for a critical part in a brand new automobile transmission for 1958. These seamless mechanical tubes, a product of Pittsburgh Steel Company, will be cut to size on the machine in the background and processed into shafts for grade retarders.

Developing and producing a new transmission for a leading car challenges suppliers as well as the automaker himself.

Pittsburgh Steel Company's seamless mechanical tubes successfully met such a challenge by making good on three critical parts for a new transmission making its debut in 1958 models.

Ability of Pittsburgh Steel's tubes to meet this auto manufacturer's high requirements and rigid testing assures tube users in other fields of high, uniform quality.

Tubes from the mills of Pittsburgh Steel are used for these transmission parts:

1. Convertor Reaction Shaft—This shaft takes the torque (turning force) built up by the torque convertor and transmits that torque to the gears.

The convertor reaction shaft is made of seamless mechanical tubing with an outside diameter of 2.219 inches and an inside diameter of 1.505 inches. It is cut to size, centered, given centerless grinding, heat treated and broached—or sized—to a tolerance of .001 inch. Welding and final processing follow.

2. Grade Retarder Shaft—This part is a new feature in auto transmissions. It gives cars a new driving range which improves control on steep downgrades and on slippery surfaces without shifting gears.

The shaft is made of tubing 2.375 inches outside diameter and 1.531 inches inside diameter.

3. Front Pump Driven Gear—This gear is an essential part of the new transmission's hydraulic control system. It maintains correct oil circulation and pressure within the transmission.

The finished gear, measuring $4\frac{3}{16}$ inches o.d. and approximately $\frac{5}{8}$ inch on the i.d., has 36 gear teeth. The teeth are broached simultaneously on a vertical broacher.

All three parts are made from carbon steel seamless mechanical tubing which is cold drawn and finished to

Convertor reaction shafts, made from Pittsburgh Steel's seamless mechanical tubing, are assembled into transmission cases at this station in an automaker's huge plant. The shaft transmits torque to the gears.

exacting specifications. The automaker who chose Pittsburgh Steel's tubing for three transmission parts carefully spelled out his specs for fine grain structure, machinability and weldability.

Those specifications were met by skilled tube mill men so that finished tubes were uniform—from length to length and from one shipment to another.

A measure of their skill is demonstrated by broaching which gives tubing grain structure a critical test. Rejects from peeling or chipping drop with Pittsburgh tubes.

Coming off an automated production line, these gears will be assembled into a front pump on a new type of auto transmission.

Machinability also is a severe test. In operations where tolerances are held to one-half of one thousandths of an inch, good machinability results in even, smooth production of parts which will pass sharp eyes of inspectors.

Welding operations carried on in automated lines can't be a haphazard operation or one in which quality of welds isn't uniform. Here again Pittsburgh Steel tubes keep production flowing smoothly and produce welds which hold up in field service.

Whether you're making automobile transmissions, hydraulic cylinders, axles or any other product requiring good tubing, you'll profit when you turn to Pittsburgh Steel. Skill of the men in the mill, modern equipment, engineering and metallurgical service available all combine to give you a satisfactory product—one backed by service and dependability.

Act today to get better tubes and service. Telephone or write the nearest district sales office listed below. You'll be glad you did.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

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Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

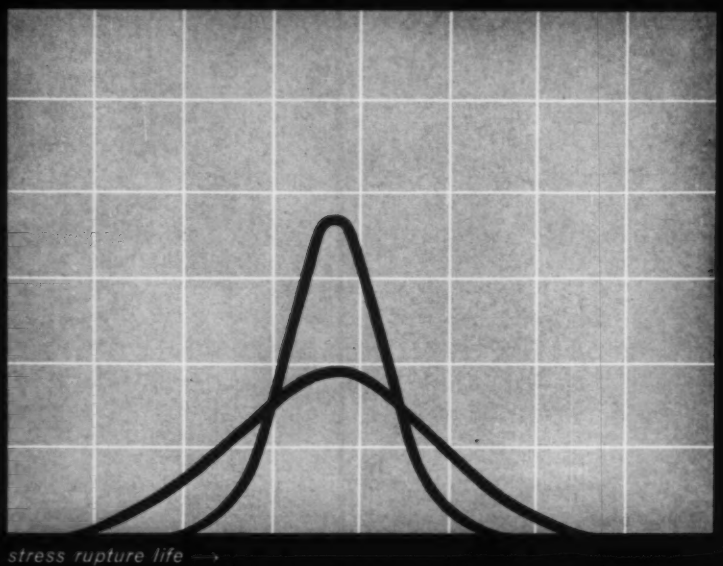
Grant Building • Pittsburgh 30, Pa.

District Sales Offices

Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 454 on Page 19

comparison of typical frequency distribution curves of rupture strength in elevated temperature alloys of the same average strength.



why consistency is important to every designer who uses elevated temperature alloys

The broader curve is characteristic of elevated temperature alloys generally used today. Its shape shows parts made from this alloy will have widely varying service lives.

The steep curve is typical of Carpenter alloys for elevated temperature service. It shows one reason why Carpenter alloys are becoming so widely used — they're so consistent in performance.

Fabrication properties are just as outstanding. Forge shops, fastener makers, engine builders report better finishes and fewer rejects with Carpenter high temperature alloys than with similar types produced by others. Carpenter alloys have gained an enviable reputation for exceptional cleanness, forgeability and machinability wherever they are used.

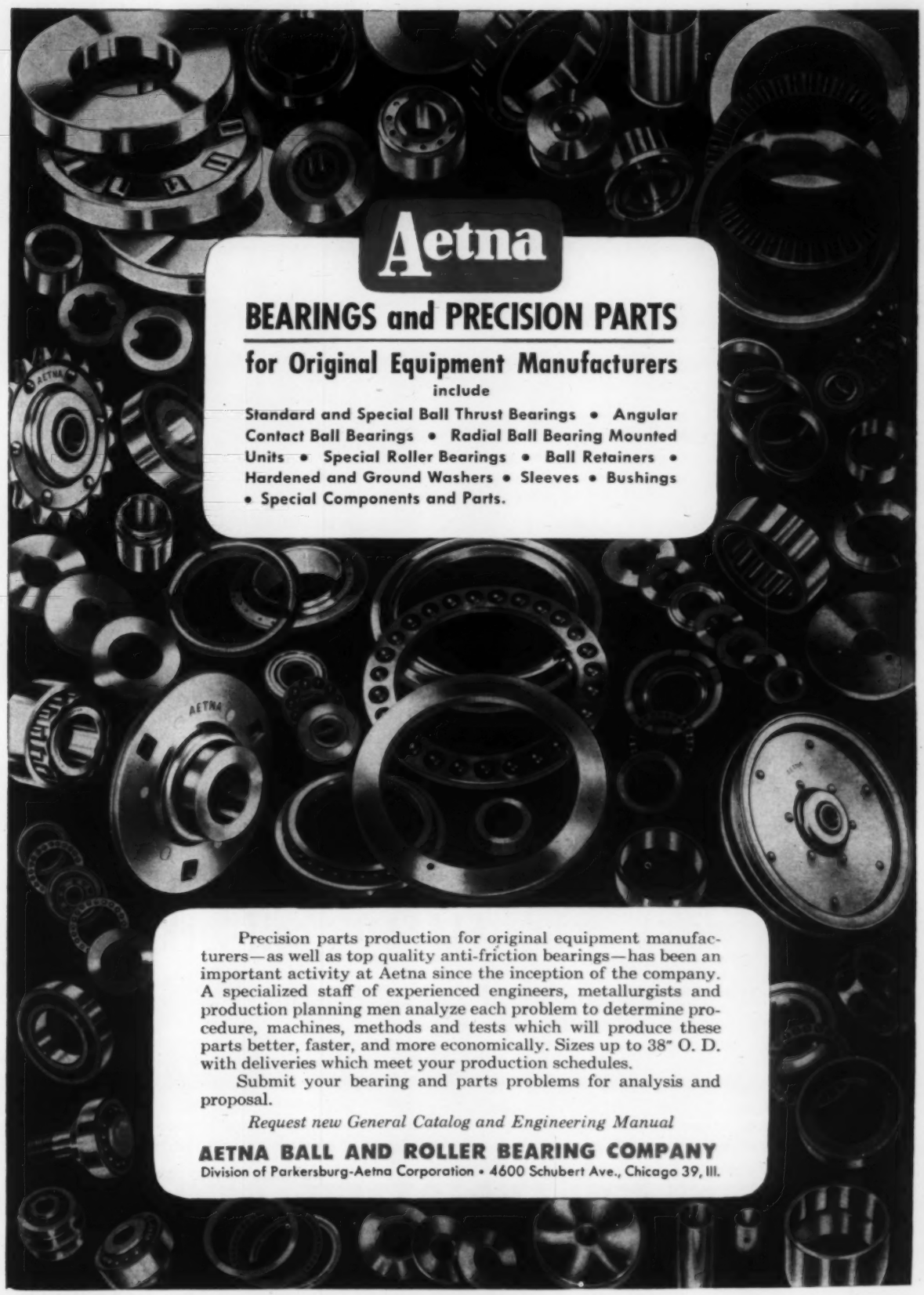
Predictable performance and outstanding fabrication properties of Carpenter elevated temperature alloys are made possible by the most exacting standards of quality control, typical of Carpenter's leadership in the technology of specialty steels.

Write today for your copy of the new booklet, "Carpenter Alloys for Elevated Temperature Service". Or ask the Carpenter representative who calls on your company. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

Circle 455 on Page 19


Aetna
BEARINGS and PRECISION PARTS
for Original Equipment Manufacturers
include
Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Radial Ball Bearing Mounted Units • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings • Special Components and Parts.
Precision parts production for original equipment manufacturers—as well as top quality anti-friction bearings—has been an important activity at Aetna since the inception of the company. A specialized staff of experienced engineers, metallurgists and production planning men analyze each problem to determine procedure, machines, methods and tests which will produce these parts better, faster, and more economically. Sizes up to 38" O. D. with deliveries which meet your production schedules.
Submit your bearing and parts problems for analysis and proposal.
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Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable . . . must stand up under vibration, temperature extremes and hard use . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners. Write for free booklet.

STANDARD PRESSED STEEL CO.

FLEXLOC® LOCKNUT DIVISION

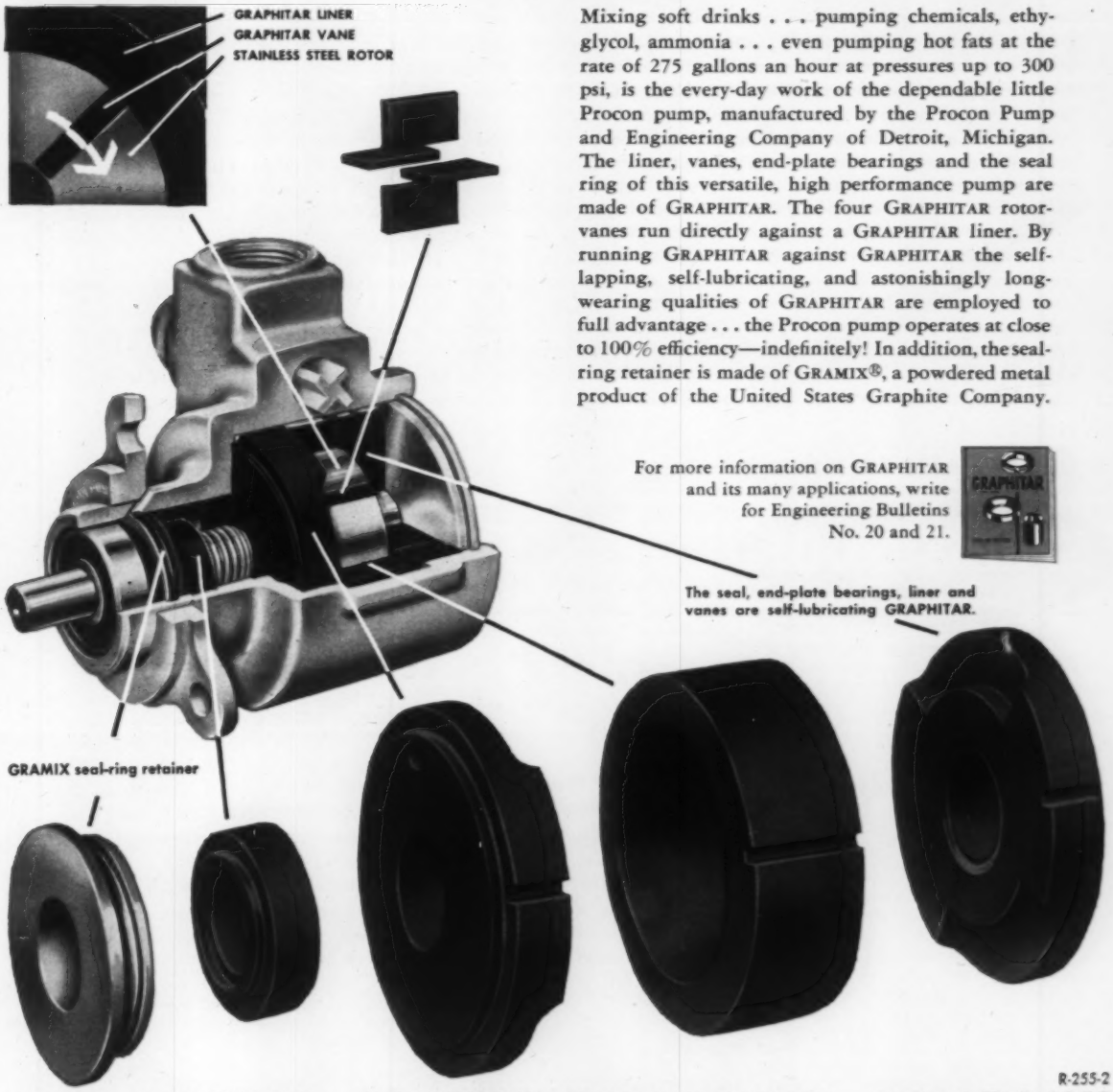
SPS
JENKINTOWN PENNSYLVANIA

Circle 457 on Page 19

GRAPHITAR® running against GRAPHITAR

(CARBON-GRAPHITE)

gives PROCON PUMPS amazing performance in handling *ALL TYPES OF FLUIDS*



Mixing soft drinks . . . pumping chemicals, ethyglycol, ammonia . . . even pumping hot fats at the rate of 275 gallons an hour at pressures up to 300 psi, is the every-day work of the dependable little Procon pump, manufactured by the Procon Pump and Engineering Company of Detroit, Michigan. The liner, vanes, end-plate bearings and the seal ring of this versatile, high performance pump are made of GRAPHITAR. The four GRAPHITAR rotor-vanes run directly against a GRAPHITAR liner. By running GRAPHITAR against GRAPHITAR the self-lapping, self-lubricating, and astonishingly long-wearing qualities of GRAPHITAR are employed to full advantage . . . the Procon pump operates at close to 100% efficiency—indefinitely! In addition, the seal-ring retainer is made of GRAMIX®, a powdered metal product of the United States Graphite Company.

For more information on GRAPHITAR and its many applications, write for Engineering Bulletins No. 20 and 21.

The seal, end-plate bearings, liner and vanes are self-lubricating GRAPHITAR.

R-255-2

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

Circle 458 on Page 19

8-year accelerated tests at HARVEY ALUMINUM prove LaSalle STRESSPROOF® and FATIGUE-PROOF® better than heat treated steel of even higher

...also cut costs by 25%

The design requirements of the new Harvey Aluminum Reduction Plant at The Dalles, Oregon, demanded the best available materials. Harvey is the largest independent fabricator of wrought aluminum mill products, and, *as a metallurgical concern, their manufacturing requirements go beyond ordinary interests.*

One of the vital components of the plant is the anode jack assembly. The assembly operates under a 60-ton load and under adverse conditions. Failures here cannot be tolerated because they would stop production and create a tough maintenance problem.

The chief project engineer knew he could not take chances . . . and set up tests simulating as nearly as possible actual operating conditions. Sample parts were made from those grades of steel bars which appeared to be most suitable.

In comparative accelerated tests, considered the equivalent of 8 years' service, STRESSPROOF and FATIGUE-PROOF were selected not only for the necessary properties but because they performed best under these rigid tests.

Vendors making the parts also found that these steel bars consistently machined easier than the heat treated steels and cut their costs.

GROUND AND POLISHED

STRESSPROOF®

WITH COPPER

PROVED BETTER THAN:

A-4140—Heat Treated Rc28-30

C-1040—Heat Treated Rc28-30

C-1144—Cold Drawn and Strain Relieved

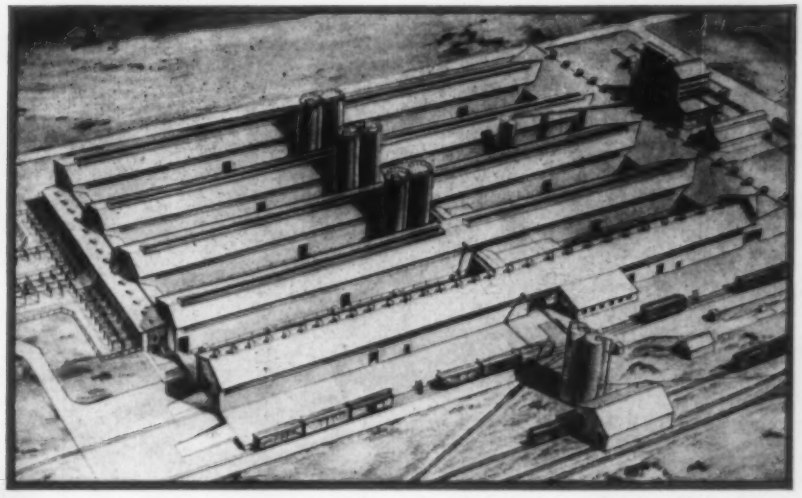
2,025 better shafts ...at 25% savings

TEST No. 1: After submitting sample shafts of each of the analyses shown at the left to the accelerated tests for wear, strength, and overload, STRESSPROOF anode shafts were proved superior. (1) STRESSPROOF gave consistent and faster machining. (2) STRESSPROOF shafts required no straightening. Other materials warped after machining. (3) STRESSPROOF showed excellent wear characteristics under applied load. (4) STRESSPROOF shafts were produced at a savings of 25% over the other materials tested.

La Salle STEEL CO.

1426 150th Street, Hammond, Indiana

steel bars hardnesses



Harvey Aluminum Reduction Plant, The Dalles, Oregon.

fatigue-proof®
STEEL BARS

MADE BY **e.t.d.** PROCESS
Elevated Temperature Drawing

PROVED BETTER THAN:

A-4140—Heat Treated Rc35-38
A-4130—Heat Treated Rc35-38
A-5160—Heat Treated Rc35-38
C-1048—Heat Treated Rc38-40

2,025 better worms ...at 25% savings

TEST No. 2: Sample bars of each of the analyses listed at the left were also put through a test equivalent to 8 years' operation. After completion of tests, FATIGUE-PROOF steel showed excellent ability to work-harden and to withstand operating loads. Machinability was superior to the other grades tested and total cost of producing the worm gear was reduced by 25% with the use of FATIGUE-PROOF steel.

also available from your steel service center

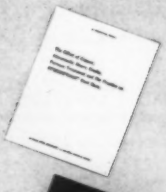
LA SALLE STEEL CO.
1426 150th Street
Hammond, Indiana

*name*_____

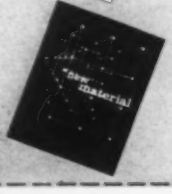
*company*_____

*address*_____

*city*_____ *state*_____

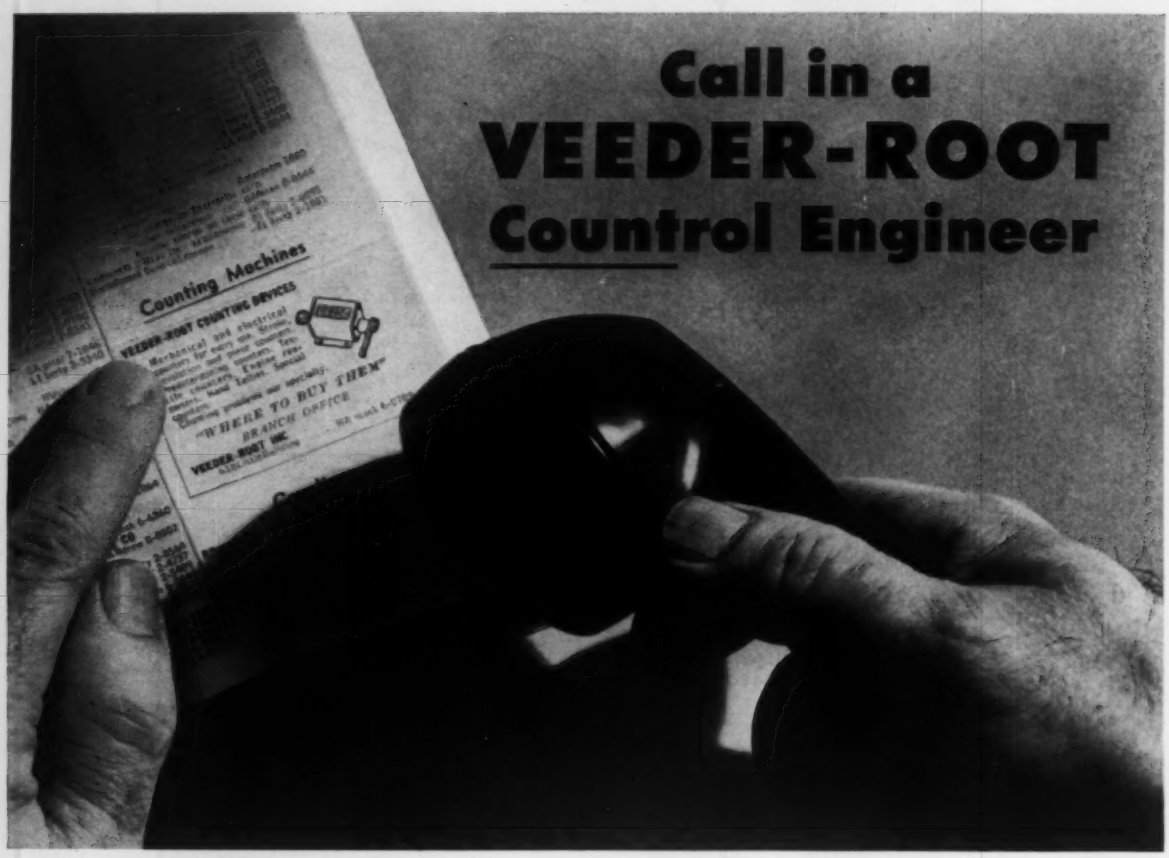


☐ Please send the newly published engineering report, "The Effect of Copper, Abnormally Heavy Drafts, Furnace Treatment and Die Practice on STRESSPROOF Steel Bars."



☐ Please send 24-page bulletin, "A New Material," which presents the results of more than one year's tests and reports on eight application case studies of La Salle FATIGUE-PROOF steel bars.

When it comes to Counting...PUT "first things first!"



"Design them in, when you begin" . . . that's the way to *integrate* Veeder-Root Counters into a new product or process. And the quick way to do this is call the nearest Veeder-Root office and ask for an engineer.

You can count on this man to save you time and money in engineering, purchasing and assembly. For he can often save you the premium cost of a special counter by adapting or modifying a standard counter to do the job you want done . . . whether it's to give you or your customers direct readings . . . remote indication . . . facts-in-figures for production, wage-payment or stock *Count*rol . . . or proof of performance-guarantee.

So when it comes to counting, call the local office or the Hartford plant, JAckson 7-7201.

Veeder-Root

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NEW ADDITIONS TO THE MOST COMPLETE LINE OF ELECTRICAL, MECHANICAL & MANUAL COUNTERS

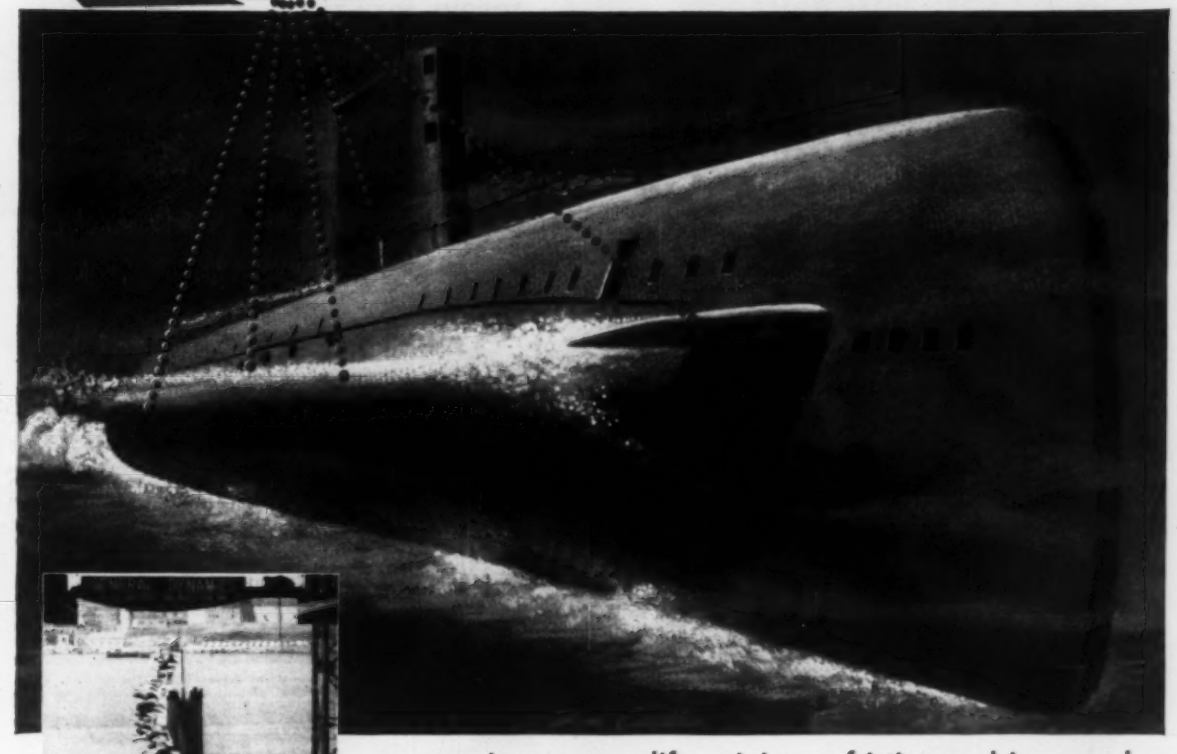
New Electric Predetermining Counter

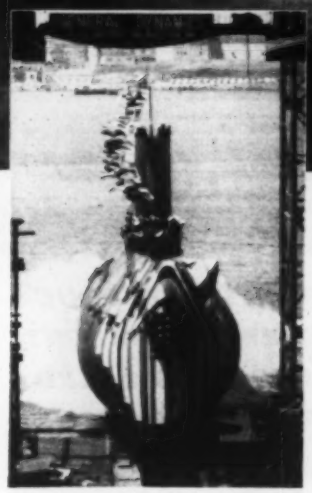
New Printed-Circuit Data Readout Counter

New Panel-Mount Magnetic Counter with Lock-Key Reset

Circle 460 on Page 19

Electrolized for Reliability...





Launching the Skate
at General Dynamics Corporation's
Electric Boat Division Shipyard

The Skate, third U.S. atomic submarine, slides down the ways at Groton, Conn., leaving behind its future nuclear companions, Skipjack and Triton.

Photo courtesy Electric Boat Division

. . . maximum wear life, minimum friction and increased corrosion resistance imparted to critical wear parts in U.S. Nuclear Submarine Fleet

Reliability of mechanisms in the Skate, the nation's third nuclear submarine, is heightened by specification of Electrolizing on more than fifty different critical wear parts. Exhaustive testing prior to specification established that Electrolizing provides superior anti-seizure characteristics . . . an extremely low coefficient of friction . . . remarkable wear resistance . . . and beneficial resistance to corrosion.

Wherever reliability is a primary consideration, Electrolizing is the answer. The Electrolizing deposit is an extremely hard (70-72Rc), dense, non-magnetic alloy which can be applied to both ferrous and non-ferrous metal surfaces. It has no adverse effect on the basis metal . . . can be held to a tolerance of .000025" . . . cannot be separated from the basis metal by peeling, chipping or flaking . . . does not "build-up" or cause nodulation on sharp edges . . . and can be held to two light bands flatness.

Four Electrolizing plants conveniently serve all U.S. industrial centers with delivery "as scheduled".

For complete data, send for new 24-page booklet. ▶

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Please send new 24-page booklet.

Name.....

Company.....

Telephone No.....

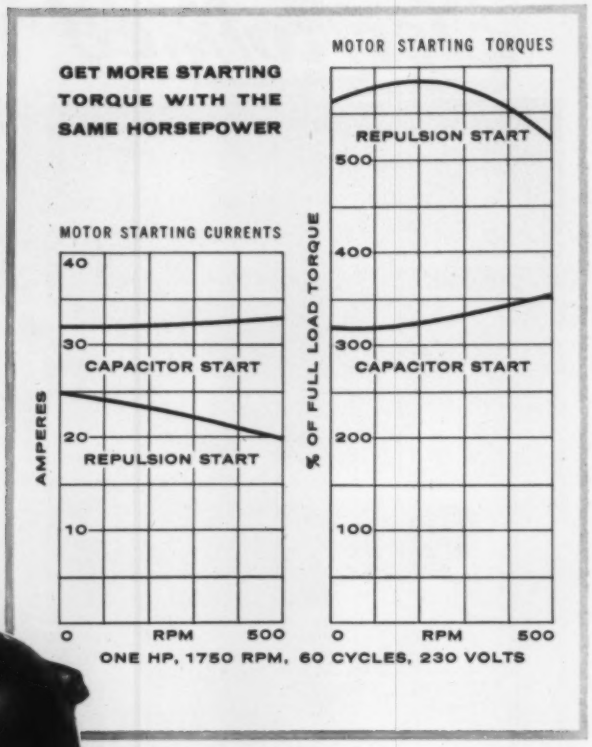
Street Address.....

City..... Zone.... State.....

Circle 461 on Page 19

WAGNER SINGLEPHASE MOTORS

This two-in-one motor is your best choice FOR HARD-TO-START LOADS



H. P.	OLD FRAME SIZE	PRESENT FRAME SIZE
1	203	182
1½	204	184
2	224	213
3	225	215
5	254	254U

Integral ratings, 1-5 hp are available in the latest NEMA Frame Sizes

4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor start motors of the same ratings.

The Wagner Heavy Duty Type RA Repulsion-Start Induction Motor offers:

- *HIGH STARTING TORQUE*
- *LOW STARTING CURRENT*
- *HIGH OPERATING SPEED*
- *FLAT EFFICIENCY CURVE*

The Wagner Type RA is the work horse of the singlephase motor field. It combines high starting torque for quick, easy starts with low starting current and minimum light flicker. It has a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough singlephase applications with Wagner RA Motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office, or write for Bulletin MU-220.

Wagner Electric Corporation
SERVING INDUSTRY SINCE 1891

WM58-2

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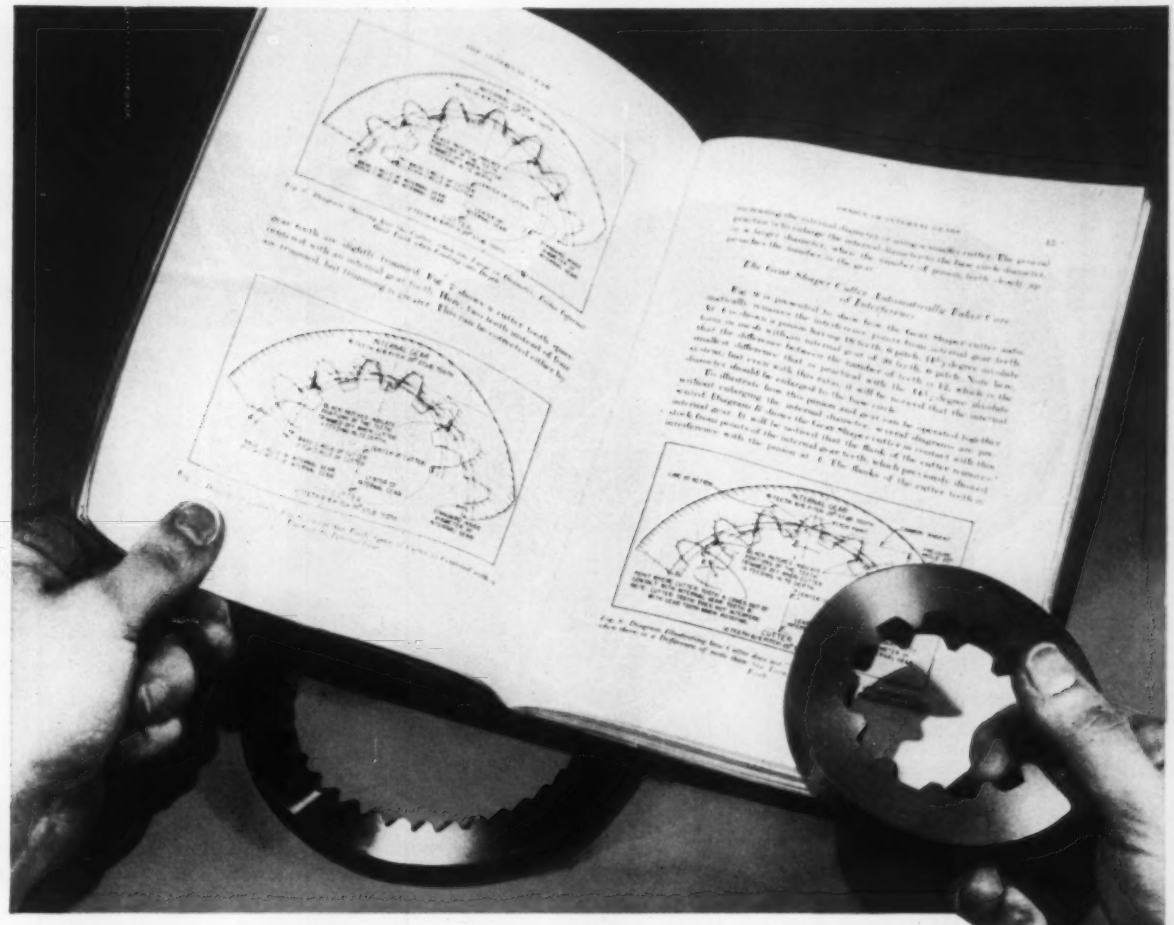
6404 Plymouth Ave., St. Louis 14, Mo., U.S.A.

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC



What every designer should know about
INTERNAL GEARS and GEARING

The internal gear, although it has certain limitations, has a number of advantages over the external gear, especially from the standpoint of compactness of design and more efficient tooth action. Most of the so-called limitations can be readily overcome by a proper understanding of the conditions to be met.

These advantages and limitations are explained in "The Internal Gear", a complete treatise on Internal Gear Design. This booklet contains information on the design and cutting of internal gears, clutches and splines, the analysis of gear tooth action and the calculation of gear tooth strength. Just write to any Fellows office for your copy.

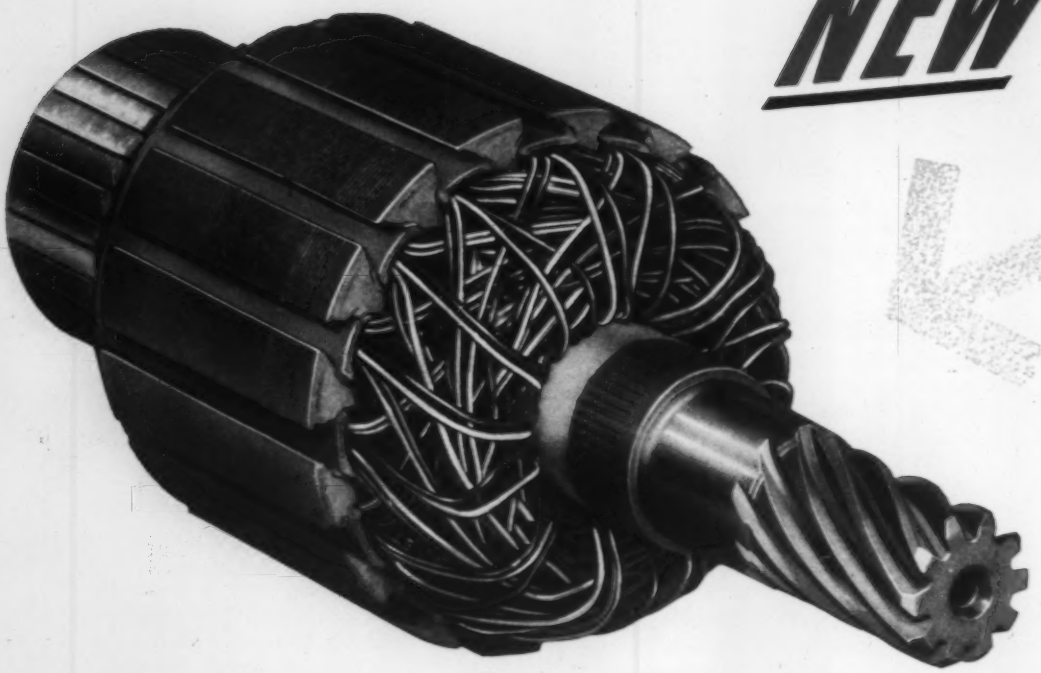
Internal gears, as well as an almost unlimited variety of other internal contours, can be produced at low cost on Fellows Gear Shapers. In many cases the same Gear Shaper cutter can be used to cut both the internal gear and its mating pinion. Production is as simple as the production of external gears.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices:
1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N. J.
5835 West North Avenue, Chicago 39
6214 West Manchester Ave., Los Angeles 45

THE PRECISION LINE

Fellows *Gear Production Equipment*

NEW



THESE 4 FEATURES MAKE NEW R & M ARMATURES OUTSTANDING

■

All coils are wound simultaneously. Coils are exactly identical, assuring identical electrical and physical characteristics. Conventional methods produce windings with individual coils having varying amounts of wire and consequent non-symmetry.

■

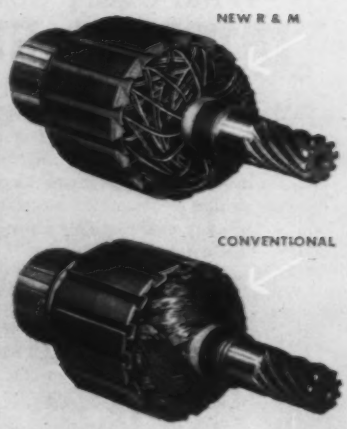
Armature coils are uniformly positioned and anchored securely. Interlocked winding pattern resists conductor and coil end movement. This unique construction minimizes abrasion of wire insulation, a common cause of high speed armature failure.

■

Maximum coil end exposure resulting from distinctive winding pattern permits maximum heat dissipation. Lower temperatures prolong armature life.

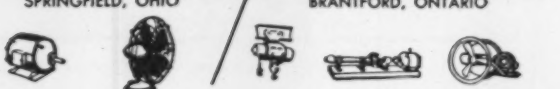
■

More uniform electrical characteristics reduce arcing at brushes, improving commutation and prolonging brush life.



ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

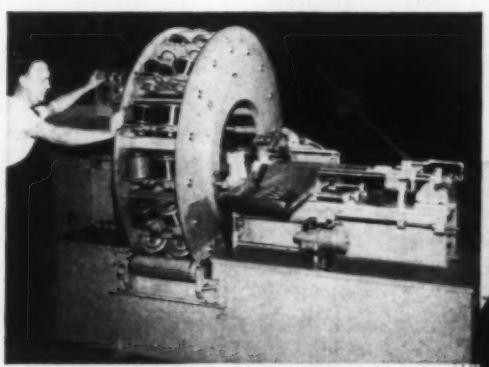


R & M PRECISION MACHINE-WOUND ARMATURES

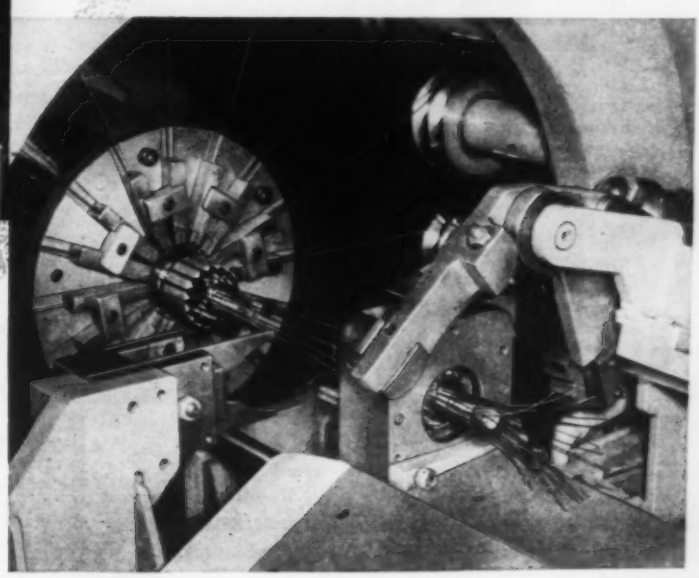
can improve your product's performance!

A new basic development in armature winding technique, perfected by Robbins & Myers, now produces armatures for Universal or Series Motors which are superior to those heretofore available for original equipment manufacturing. The new R & M armature winding machine winds all coils simultaneously . . . uniformly positions them . . . and the coils are physically and electrically identical! Weaknesses inherent in armatures wound by conventional methods are eliminated. The new R & M machine produces armatures of finer, more uniform construction which will give longer, more dependable service!

Contact a Robbins & Myers representative for additional details on R & M universal motors and series motor parts or write for Bulletins 444-MD and 455-MD.



AUTOMATION AT R & M SPEEDS ARMATURE WINDING AND IMPROVES ELECTRICAL AND PHYSICAL QUALITIES OF PRODUCT.



R&M

ONLY Eastman

CAN GIVE YOU THIS COMBINATION...

EXCLUSIVE EASTMAN PACKAGE

1 ***Exclusive*** **Eastman Inter-Lock® Clamp for Best Hose Connection.**

Exclusive grip advantages offered in no other clamp. Accurate machining assures positive positioning. Hose is uniformly compressed between insert and clamp without pinching or weakening, creating Eastman's exclusive "Inter-Lock" grip.

2 **Eastman Split Flange for Tighter Seal at Higher Pressures.**

Cuts production and replacement costs with a No-Thread, No-Leak "O" Ring Connection which eliminates tapered threads, sealing compounds and spiral leaks—as well as housing distortion.

Only Eastman can give you this Split Flange Clamp and exclusive Inter-Lock Coupling Combination. *Only* when you specify Eastman can you get the advantages of both. *Only* Eastman can give you this convenient one-source package.

This combination is ideal for *Original* heavy duty equipment. It is the only answer to high pressure requirements because it meets highest OEM specifications and easy field replacement needs.

Available with stem inserts in angles from 0° thru 90°; sizes from ¼" thru 2"; recommended pressures from 375 p.s.i. to 5000 p.s.i.

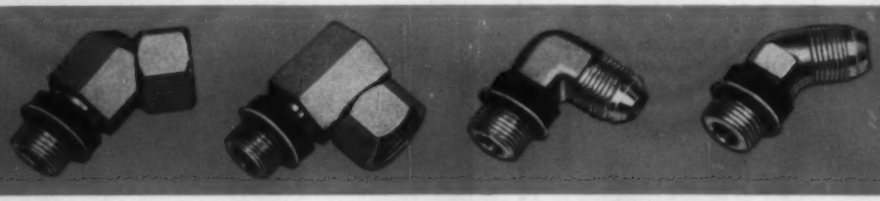
Look to Eastman . . . America's No. 1 OEM specification . . . for all your fluid power line requirements . . . for the best assembly, the best performance, the best service. Eastman is also recognized for its leadership in engineering design and development . . . backed by unequalled years of experience in the field. *It pays to submit your original specifications for your first quotation to Eastman!*

EASTMAN SPLIT FLANGE

Eastmon offers you the famous patented split flange design which assures a tilt and blowout proof clamp. "The higher the pressure the tighter the 'O' Ring seal."

Eastman "O" Ring Boss Fittings

Now available with new "Back-up" washer and locknut eliminating "O" Ring extrusion per SAE specifications.



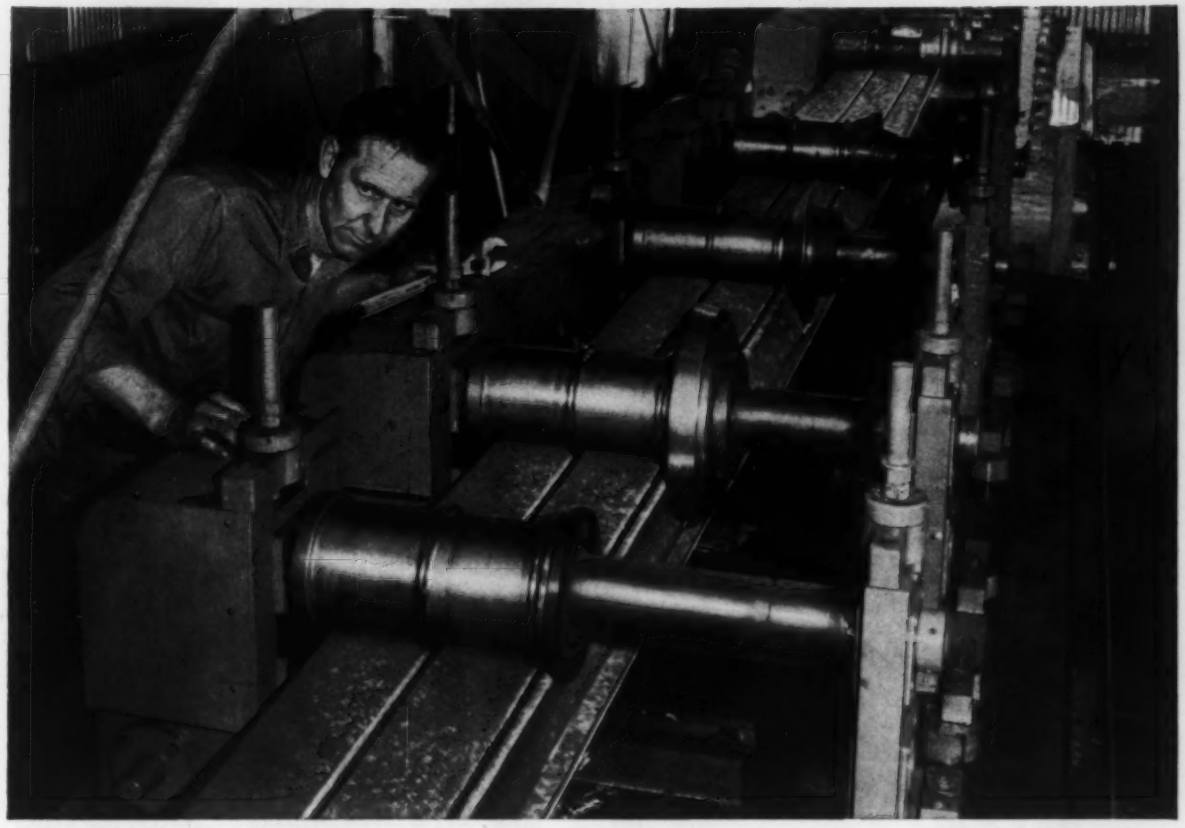
Eastman
first in the field

Manufacturing Company
Dept. MD-1
Manitowoc, Wis.

DESIGN AND DEVELOPMENT ENGINEERS:

Write for Technical Bulletin 200 for Information and Specifications on Complete Eastman Line of Hydraulic Hose Assemblies, and Bulletin 40 on Inter-Lock clamp.

Circle 465 on Page 19

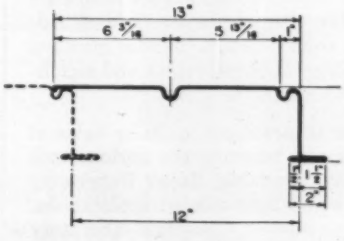


Continuous rolling of roof deck severe test for Bethcon

Builders and architects on the Pacific Coast now have a new type of longspan structural roof deck to work with. This decking is light in weight, yet strong enough to carry the specified roof loads safely, and flexible enough to meet various detail problems easily. T Steel Roof Deck, as it is called, is made of Bethcon galvanized sheet steel by T Steel Corporation, of Seattle and Los Angeles.

Perhaps as well as anything we've seen, this T Steel Deck illustrates the versatility of continuously galvanized sheet steel. A glance at the line sketch clearly shows that this intricate rolling is an ordeal for a galvanized coating. But because Bethcon is galvanized by Bethlehem's continuous galvanizing process, the coating adheres so tightly that it doesn't peel under severe forming or bending operations.

Another feature of Bethcon which is important to T Steel Corporation is the fact that it is available in coils. Thus continuous output of the decking is possible, resulting in some substantial production economies.



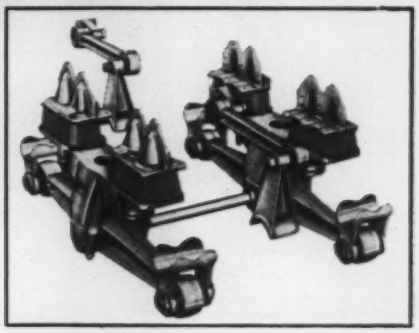
This is typical of the success stories which Bethcon is helping to achieve for manufacturers in widely differing fields throughout the country. The low cost of Bethcon, its strength, its easy formability—these and other advantages are firing the imagination of many a design engineer and production man.

Perhaps the combination of steel's strength and zinc's resistance to corrosion, as embodied in Bethcon sheets, might prove the answer to a problem of yours. Our nearest sales office will be glad to lend a hand on any project which you think Bethcon might benefit.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL



The unique design of the "load cushion" accounts for smooth, even rides in the full range of loads, empty to full. Enjay Butyl Rubber (in red) made it possible.

ENJAY BUTYL "LOAD CUSHION"

replaces steel springs in big Tractor Trailers

The "load cushion" is an important innovation in tandem suspension. Developed by the Hendrickson Mfg. Company, it is made of Enjay Butyl and replaces steel leaf springs. Utilizing the great strength and impact resistance of Enjay Butyl, the "load cushion" gives the ultimate in a soft, easy ride within the complete range of loading, from empty to full. Besides giving a smoother, steadier ride, it increases tire mileage, reduces weight and significantly reduces wear and tear on equipment.

Enjay Butyl has proved to be the answer to problems in many fields of industry. It may well be able to cut costs and improve the performance of *your* product. Low-priced and immediately available, Enjay Butyl may be obtained in non-staining grades for white and light-colored applications. Get all the facts by contacting the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY

Pioneer in Petrochemicals

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Circle 467 on Page 19

WANT TO SOLVE A METAL LABELING PROBLEM?

Here's how to make METAL* LABELS on-the-spot -in seconds!

"MIDGIE"
Portable Hand Embosser — 5/32" Type Size

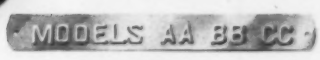
In the Lab... In the Field... In the Shop...

WHAT IS YOUR LABELING PROBLEM?

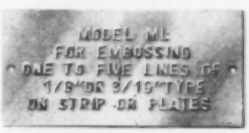
pattern numbers	storage crates	chemicals
plating	motors	storm windows
parts bins	lots-in-process	electrical parts
tools	instruments	stock shelves
machinery	shipments	plants & shrubs
dyeing vats	heat treating	cables
animal tags	dip tanks	heat equipment
wiring	badges	all-weather equipment

* Aluminum, Brass, Copper, Carbon Steel, Stainless Steel, Nickel, Monel, Zinc, Colored Metals & Many Others.

SINGLE-LINE MANUALLY OPERATED BENCH MODELS
Offered in a wide variety of type sizes & styles. From 1/8" to 1".



MULTIPLE-LINE MANUALLY OPERATED BENCH MODELS
1/8" & 3/16" Type Sizes



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Write for FREE catalog and samples to:

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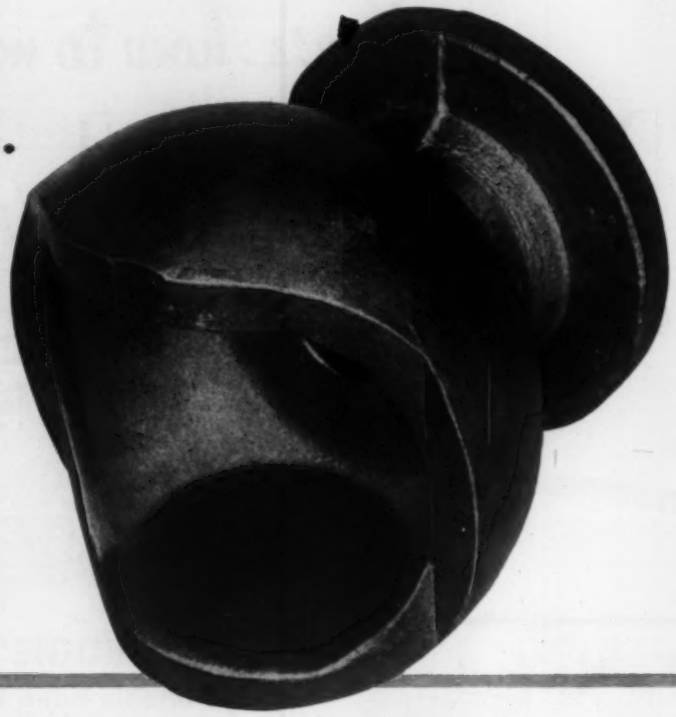
Circle 468 on Page 19

unusual design in upset forging...

BALL-JOINT HOUSING for the steering and driving mechanism of the Clark Equipment Company's line of Four-Wheel Drive MICHIGAN End Loaders and Turbo-Dozers formerly produced as a steel casting is now turned out by Commercial as a closed-die forging on an 8-inch upsetter.

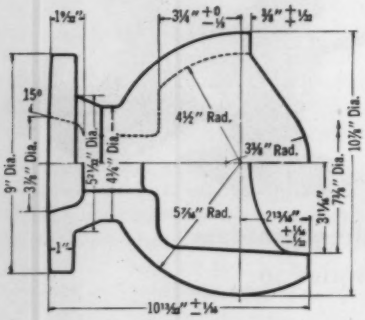


80 lb. forging replaces 95 lb. casting

A saving of 15 lbs. of metal on each housing component is only part of the impressive cost cutting story made possible at Clark Equipment Company by a switch to upset forgings.

When the parts were produced by Commercial as closed-die forgings on an 8-inch upsetter Clark Equipment reported:

1. An initial cost saving of 90¢ per part.
2. Closer tolerances for a 10% machining cost saving.
3. No rejects due to hidden metal defects.



UNUSUAL SHAPE and characteristics notwithstanding — flanged on one end, belled on the other, and open on both ends—Commercial engineers proved this part could be produced as an upset forging with greater cost savings.

Now, this important component not only costs Clark less per unit, but because of its controlled grain flow and efficient metal distribution it provides maximum tensile and torsional strength to resist unusual operating strains as well as massive and unpredictable shock and load. Longer operating life and trouble-free performance are assured.

And because forging impact and pressure produces a more dense, more uniform metal structure, forged parts absorb and dissipate heat at a uniform measurable degree. Obviously, that means elimination of distortion problems in heat treating. It also means fewer rejects during machining, since this dense uniform forged metal has no hidden internal flaws.

With new forging techniques continually unfolding to meet specific job requirements, more original equipment manufacturers are increasingly looking to upset forging to help solve their component forming problems—stronger, lighter, more compact parts at less cost per unit.

Many parts like this unusually shaped housing for Clark Equipment, which were formerly considered impossible to forge, are now routine at Commercial. An early check with Commercial's forging engineers on your particular component forming problem may pave the way for improvement in your product design and production methods—could save you time, money, and help improve performance and operating life.

WHEN AN UPSET FORGING?

Check your part forming problems against this list of "bench marks" for parts requiring:

- Reduced weight, thinner section, greater strength.
- Consistent soundness — no losses due to porosity.
- Good appearance—smooth, close-grained surface.
- Superlative shock and fatigue resistance.
- Uniform response to heat treatment.
- Cost-cutting advantages in finishing—less waste metal, reduced machining, no rejects due to hidden flaws.

Address The Commercial Shearing and Stamping Company, Dept. S-4, Youngstown 1, Ohio.

COMMERCIAL
shearing and stamping

Circle 469 on Page 19

WHEN FLUID POWER ENTERS YOUR PROJECT

call the man from Webster

. . . one of a staff of engineers, specially trained in hydraulic applications.

He is ready to come to your plant, work with your people, explore new ideas, application or system problems. His knowledge of the unique, flexible design advantages of Webster pumps and valves enables him to adapt standard components to solve most special problems . . . with resultant cost savings.

Write or call the man from Webster — a good man to have on your design team.

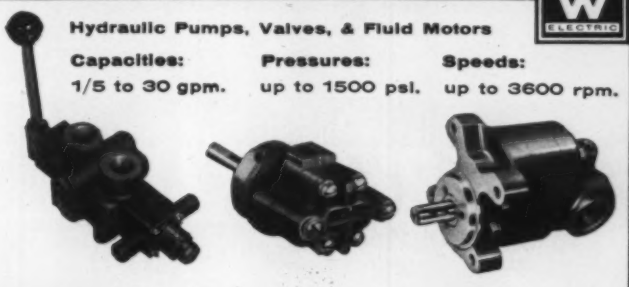
OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

Racine, Wisc MElrose 3-3511

Hydraulic Pumps, Valves, & Fluid Motors

Capacities:	Pressures:	Speeds:
1/5 to 30 gpm.	up to 1500 psi.	up to 3600 rpm.



☐ *Have THE MAN FROM WEBSTER contact us—*

- Please send the following -

☐ *Complete catalog of pumps and valves*

☐ *New information or data as published*

Name _____

Title _____

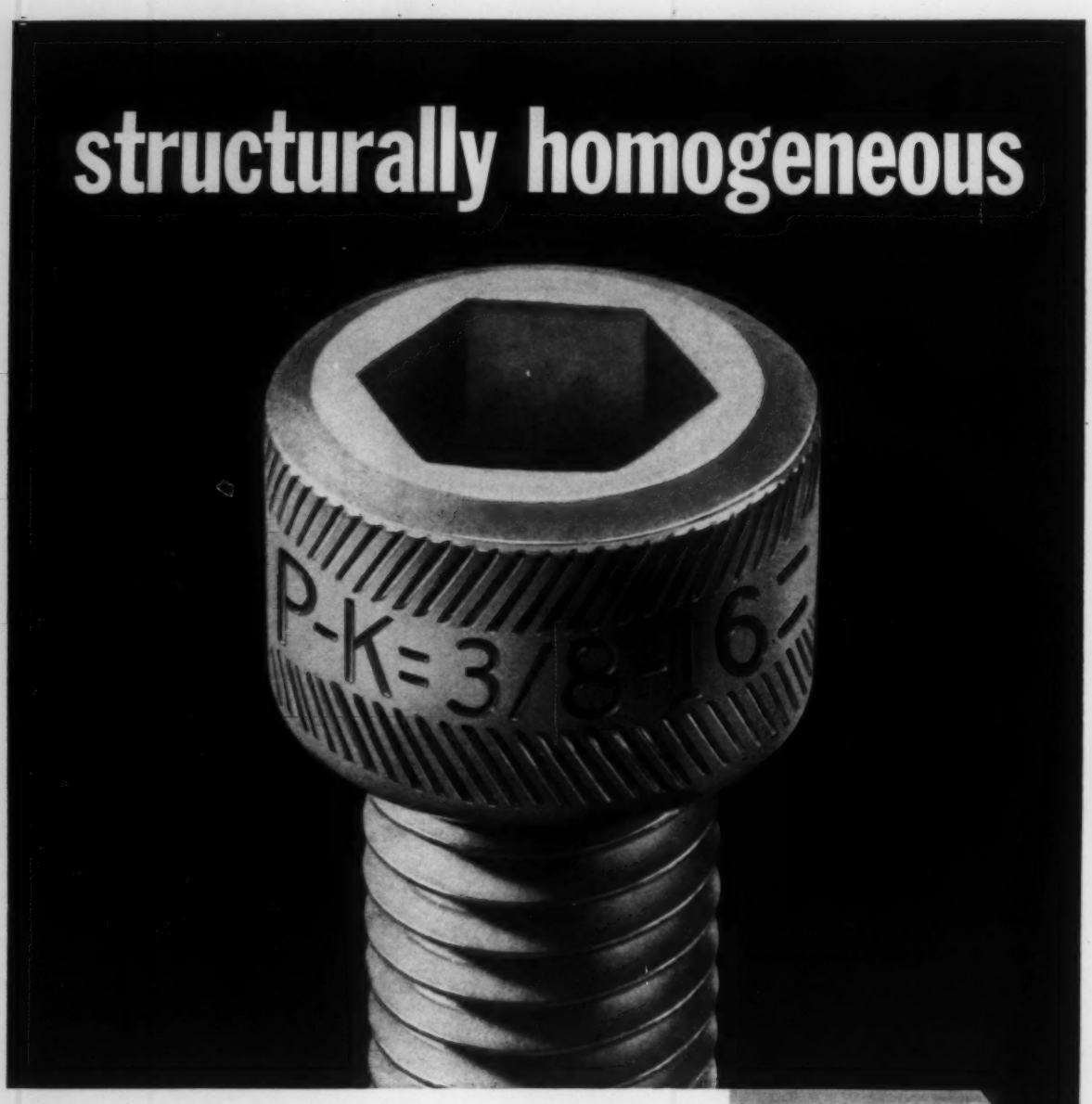
Company _____

Street _____

City _____ State _____

franklin adv. H100

structurally homogeneous



PARKER-KALON stress relieved socket screws

After controlled heating and equally controlled uniform quenching imparting maximum strength, P-K Socket Screws are carefully tempered to assure ductility, proper elongation and high impact strength. This is your assurance that . . . *If it's P-K . . . It's O-K!*

PARKER-KALON DIVISION, General American Transportation Corporation • Manufacturers of Socket Screws, Self-tapping Screws, Screwnails, Masonry Nails, Wing Nuts and Thumb Screws.

Sold Everywhere Through Leading Industrial Distributors — Factory: Clifton, New Jersey • Warehouses: Chicago, Illinois; Los Angeles, California

PARKER-KALON® fasteners

NEW, COMPACT Century 48-FRAME Fractional HP MOTORS

INDUSTRIAL QUALITY for all applications

take less space...
weigh less...
perform better!

ROTOR

Rotor bars, end rings, and fans integrally pressure-cast of virgin aluminum. Rotors dynamically balanced to very close limits; meet strict quiet-motor requirements.

INSULATION

Heavy vinyl acetal insulated wire, tough mechanically, thermally, and dielectrically, has excellent moisture resistance, highest uniformity. Stator core slots lined with cells of DuPont Mylar bonded to all-rag electrical paper.

BEARINGS

Sleeve: pressed into place in bracket which has been bored true in single set-up operation. Finish boring operation assures proper bearing surface and concentricity. *Ball:* single-shielded, precision fitted in brackets.

LUBRICATION

Sleeve bearing type: wool yarn wicking provides constant oil supply to oil groove. Inner sump cup retains excess oil which is tapped by felt wicks extending into the wool yarn. *Ball bearing type:* standard construction permits re-greasing.

GOVERNOR and SWITCH

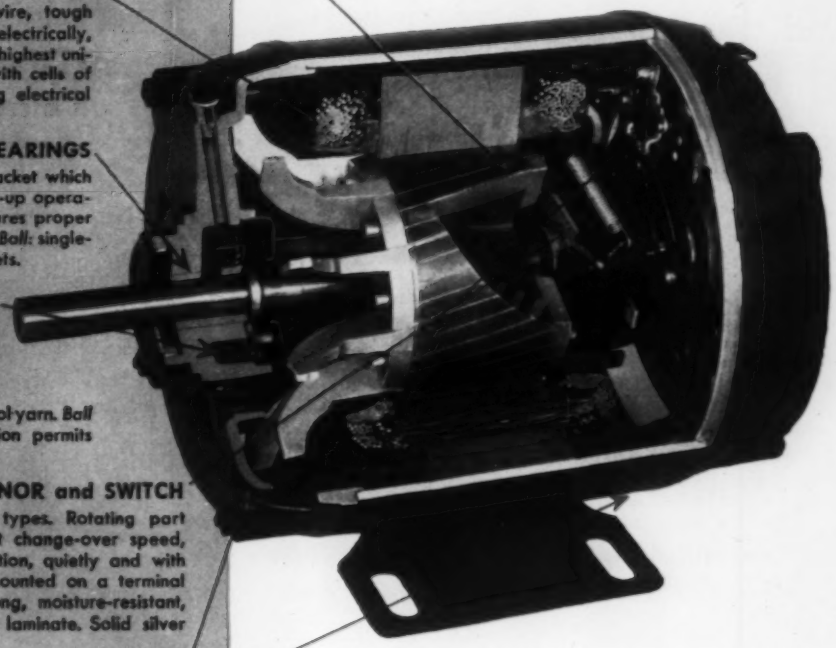
For capacitor and split phase types. Rotating part securely press-fitted to shaft. At change-over speed, governor operates with snap action, quietly and with no flutter. Stationary switch is mounted on a terminal plate; plate is GLASTIC, a strong, moisture-resistant, arc-resistant glass-filled polyester laminate. Solid silver contacts are used.

BEARING BRACKETS

Pressure cast in special aluminum casting alloy. Stress relieved for permanent stability. Strong internal ribbing for strength, and smooth outside surface.

FRAME

Stator frame rings formed of one-piece heavy rolled steel. No frame openings; windings fully protected. Rabbet fit faced and bored true to provide proper alignment of bracket and a concentric air gap. Heavy formed steel feet welded to frame ring.



Century Industrial Quality means *design* that does not compromise dependability to gain slight cost advantages... sturdy construction provides the stamina which assures continuous operation. 48-Frame Motors now available from 1/20 to 1/3 HP... Performance-Rated to your needs... with weight savings up to one-third!

Test one of these motors for yourself. Call or write your nearby Century District Sales Office or Authorized Distributor. Send for new bulletin 1-1P1.

Performance-Rated© MOTORS
1/20 to 400 HP

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

A quick way to get multiple copies of engineering drawings!

XEROX® Model 1218 COPYING EQUIPMENT

Cuts Costs—assures copies precisely like the original

24" x 36" drawing on copyboard of camera. Drawing is exposed to XeroX plate and reduced to 12" x 18" size by xerography.

Copies engineering drawings or anything written, typed, printed or drawn up to 24"x36", by xerography onto offset paper masters for runoff of 12" x 18" multiple copies on offset duplicator . . .

Using xerography and offset duplicating, one hundred copies of an engineering drawing, reduced from 24" x 36" to 12" x 18" can be produced in about five minutes. Copies are sharp with details of the original clearly readable on the reduced size.

Xerography is a dry, electrostatic, copying process requiring no intermediate negative. No sensitized papers, water or liquid chemicals are used.

COMPARE VOLUME—*Rear:* 350 Blueprints each of D-C-B and A sizes. *Front:* same quantity reproduced by xerography & offset duplicating.

ADVANTAGES OF XEROGRAPHY

Time Saving—Precut paper used instead of rolls . . . eliminates print hand-cutting operations. Also, further time is saved in handling, unfolding, refolding, and filing prints and by reduced volume.

Space Savings—Filing space saved by half-size prints and elimination of blueprints and vandykes. Several prints may be compared without overlapping.

Lower Paper Costs—Regular drawing paper may be used for originals instead of costly linen and vellum.

Dimensional Stability—Improved stability over older methods, since all process steps are dry.

Ease of Reading—High contrast, permanent, black-ink image on white paper.

Ease of Writing—Clear, white background on print suitable for notes, calculations, instructions, etc.

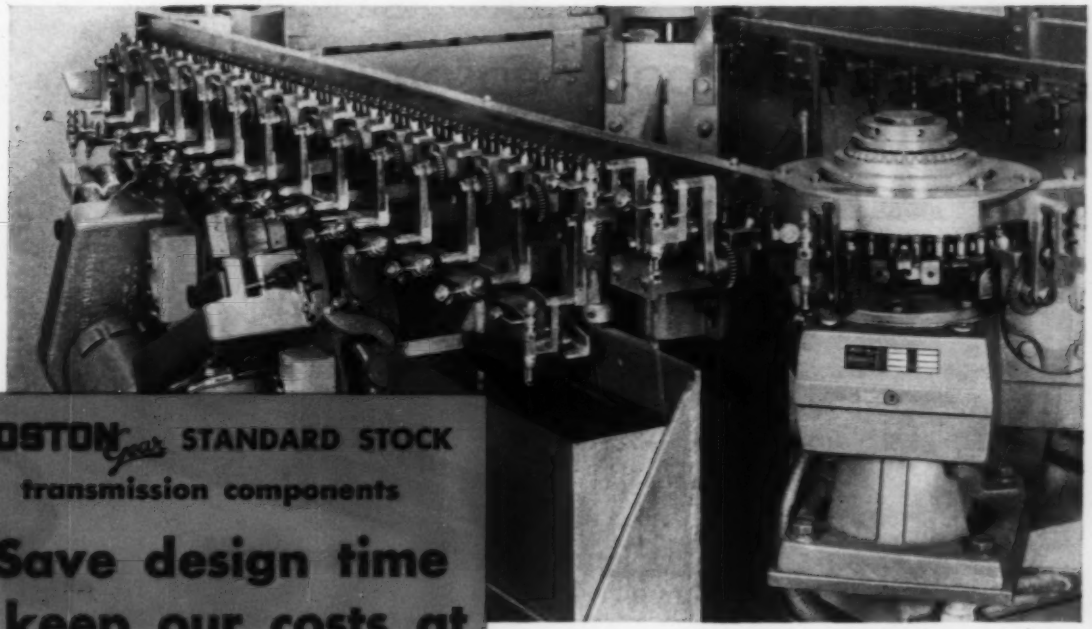
Lower Postal Charges—Decreased size and weight results in lower postal charges for transmittal to vendors and customers.

Greater Versatility—Vellum copy included in run-off may be used as an intermediate for re-runs and for reproduction by diazo at different locations.

Write for details showing how XeroX Model 1218 copying equipment speeds operations and cuts costs.

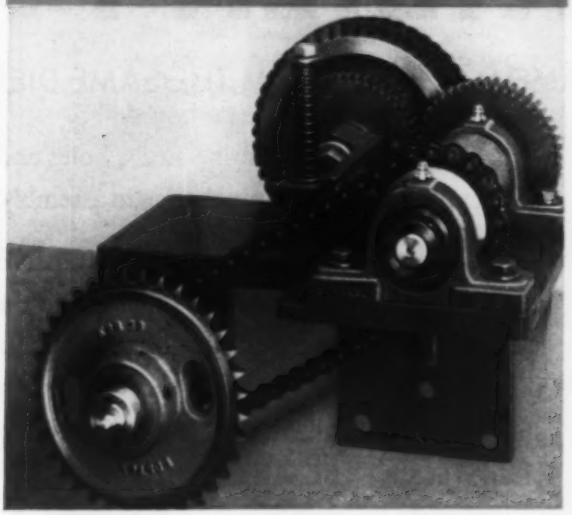
THE HALOID COMPANY, 58-181X Haloid St., Rochester 3, N. Y.
BRANCH OFFICES IN PRINCIPAL U. S. AND CANADIAN CITIES

HALOID XEROX®



BOSTON Gear STANDARD STOCK transmission components

"Save design time ...keep our costs at lowest level"



THIS SPECIAL MACHINE, *(above)* is built by the Eraser Co., Inc., for automatically stripping and soldering fuse plug lead wires. It requires the highest standards of precision and performance in all components. Assembly includes BOSTON gears, rack, pillow blocks, pulleys, sheaves, and bushings, — also the BOSTON Ratiomotor shown at the right. Manufacturer says — "In designing special machines, we use standard stock parts wherever possible. They save design time and keep our manufacturing costs at the lowest possible level."

THIS DRIVE for a rotary nylon bristle brush *(left)* is a component of an over-feed device for tentering frames made by Marshall & Williams Corp. This manufacturer of textile finishing equipment knows the many advantages of "Design around BOSTON Gear". The standard gears *(laminated phenolic)*, sprockets, chain, and pillow blocks used are all supplied from local Distributor's stock.

Design around BOSTON Gear from simple drives to full automation —

— STANDARDIZATION PAYS —

BOSTON Gear now offers more products than ever to meet any drive need, quickly obtainable "off-the-shelf" from local stocks. Your BOSTON Gear Distributor will help you simplify planning, and show you how to get the maximum benefits from standardization — in lower costs, in easier maintenance, in simplified servicing. Boston Gear Works, 64 Hayward Street, Quincy 71, Mass.

CALL YOUR BOSTON Gear DISTRIBUTOR

For nearest Distributor LOOK UNDER "GEARS" in the 'Yellow Pages'

7124 STANDARDIZED PRODUCTS OFF-THE-SHELF — AT FACTORY PRICES

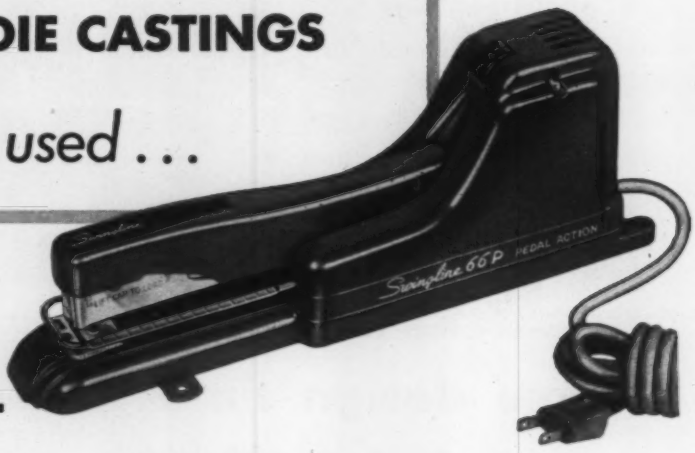
— STANDARD STOCK GEARS — SPROCKETS & CHAIN — SPEED REDUCERS — BEARINGS —

There's a Good Reason why

ZINC DIE CASTINGS

are so widely used . . .

at Swingline



IT'S FLEXIBILITY

TWO DIFFERENT MODELS OF THE SAME MACHINE FROM THE SAME DIE!

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MACHINE DESIGN
January 23, 1958

Measure of Human Benefits

SEVERAL readers have taken us rather severely to task over a recent editorial "Management's Responsibility." In attempting to make a point we were guilty of oversimplification, and the all-important qualifying statements seem to have escaped notice.

Our point was that management is money-oriented, not because of the love of money itself, but because money is the most convenient yardstick with which to measure and compare human benefits. We felt it to be important for engineers, who are in or close to management, to see this clearly, and suggested the desirability of their aligning themselves with that viewpoint.

A business enterprise, our correspondents agree, exists to fill a human need. Five major groups benefit: Owners, employees, suppliers, customers, and government.

Owners receive profit. Where does it go? Some is put back into the business to improve its effectiveness in filling human needs. The rest goes directly to people—including widows and orphans—as stockholders or through stock-holding insurance companies in benefits.

Employees — including management people—receive salaries and wages which buy food, shelter, clothing, transportation, and recreation for their families.

Suppliers receive payment for goods and services which they in turn, being business enterprises themselves, distribute to more people.

Customers receive goods or services. With these they satisfy their own needs and desires—or help run more businesses to benefit more people.

Government has been called the predatory partner. But even taxes benefit people. They help maintain national security, domestic law and order, public works, and countless services. They also provide the necessities and luxuries for more people on national and local government payrolls.

We said in the original editorial: "The most successful managements are the ones that make the most money for the most people." A foundry could make castings galore without benefiting anybody; if the product couldn't be sold at a profit the owners, employees, and suppliers would starve and the rest of us would pay higher taxes. Such an enterprise would serve no useful purpose. To benefit people it must make money—a measure of service to humanity.

Colin Carmichael

EDITOR

Engineers team up

MANAGEMENT

By KEITH C. HARDER
Training Specialist
Office of Naval Research
Department of the Navy
Washington, D. C.

ENGINEERING administration is a skill—based on the use of information, principles, procedures, and processes. It has been defined as the application of manpower, materials, and money to accomplish a task. Most engineers recognize that there is a body of management knowledge about which they must become informed if they are to advance. Unfortunately, there is disparity between the academic preparation of a typical engineer and his future utilization.

On his first job he needs only command of the simpler technical aspects of engineering. As experience is gained, confidence and skill in applying technical knowledge increases, and the engineer advances in responsibility in his field. With this growth, he finds he must assume increasing responsibility for assigning engineering tasks to others. A significant but often unnoticed change in the character of his assignments has begun. He is beginning to do work for which most engineering schools have included no academic preparation.

It is strange that developing skill in directing the work of others is not a significant part of the curriculum of many engineering schools. And this is particularly unfortunate since it is a common observation that only one in seven employees fails because of lack of technical knowledge; six out of seven failures result from an inability to manage and work with people. This important ingredient is often left to the teachings of experience.

The picture is changing rapidly, however. Industry, universities, consulting firms, technical societies and associations, and the military services are all making efforts to meet the recognized needs of technical personnel to become better equipped to solve managerial problems. The author has participated in two significant projects, an account of which may give some insight into principles, techniques, and procedures which may be helpful to individuals, institutions or companies considering the establishment of management development programs.

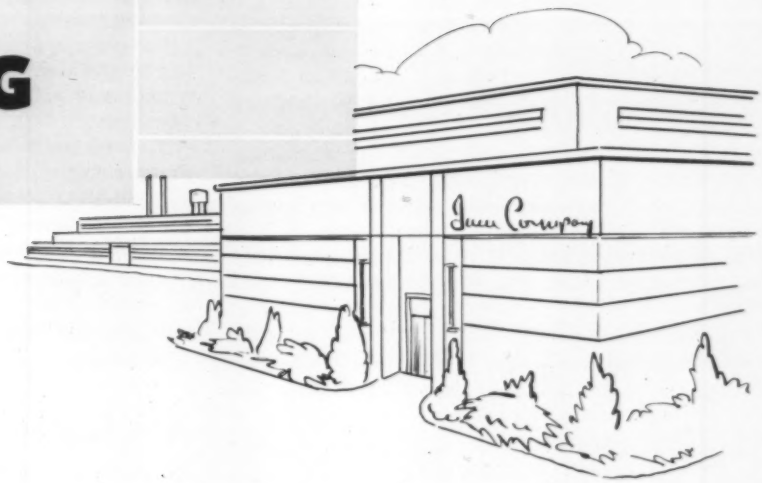
One such project was the establishment of a Master of Engineering Administration program by George Washington University for scientists and engineers employed by the federal government and private industry in the Washington area. The second project was participation as a member of the Graduate Study Commission of the American Society for Engineering Education. Aim of the commission was to make an intensive study of facilities and opportunities for graduate study in engineering.

Problems of setting up and running a program

Experience is not always the best teacher—particularly for the engineer who must develop skill in management. One approach to better training in management principles and procedures is provided by a college-level course, designed with industry - university co- operation. Here is how George Washington University tailored a program to fit the needs of engineers in its area.

with college and company for

TRAINING



of engineering administration are considered here under these categories:

1. The community conditions
2. The educational institution
3. The supporting companies
4. Needs of the engineer-students
5. Nature of the curriculum
6. Quality of instruction
7. Scheduling
8. Student counseling
9. Communication
10. Evaluation of results

Are Community Conditions Favorable?

Here's what's needed—

- **enough engineer-residents**
- **an interested educational institution**
- **supporting companies**
- **a motivating force**

There must be an appropriate combination of four factors in a community where a university-level program in engineering administration is to succeed:

1. A considerable number of engineers in the commuting area must feel a need for a better understanding of management.

2. The community must have access to the facilities of an educational institution, one which has an enthusiastic interest in setting up a management program. If the college or university officials really want to help local industry to improve management, ways can be found to solve many of the problems that arise.

3. Either one large or several small companies employing engineers must show interest in the project.

Many communities which have the interested engineer-residents, an educational institution, and the supporting companies have not established programs for management improvement and development. This indicates that there is another important element—motivation. Better management know-how must be desired intensely enough for somebody to do something about it. Either an individual or a group must be enthusiastically concerned about the establishment of such a program. It may be a staff member of a college or a university; it may be the owner, manager or an employee of an engineering company; or it could be a member of one of the technical societies.

In the Navy Department, the motivating force was provided by two training officers who recognized the need, conducted surveys which verified the need, and led the way in establishing the graduate-level management program at George Washington University.

Is the College Interested?

If so, here's its job—

- **lay out the program**
- **provide the staff and facilities**
- **maintain quality**
- **check on financial soundness**

The first question asked by educational-institution administrators when a management program

is proposed is this: What are the implications and duties for the educational institution, and its administrators, when it accepts responsibility for a degree program in engineering administration? Briefly, here is what it must do:

1. Determine the subject content of the program.
2. Maintain high standards.
3. Make certain that facilities are adequate.
4. See that the program is financially sound.
5. Provide a qualified faculty, including a nucleus of full-time staff members to give guidance and leadership.
6. Determine and control admission standards.
7. Select, if needed, part-time teachers from industry and other sources and see that they are integrated with the full-time faculty.
8. Plan the program so that its scope, variety of courses, sequence, schedule of classes, and duration are such that the purpose of the program is achieved.

By carrying out these duties, the educational institution helps to insure that the program will be of high quality. If a nondegree program is established, reasonably close attention to the same criteria insures quality of the courses.

The educational administrators will undoubtedly ask a number of further questions: At what level is the program to be taught? Is it to be designed for academic credit, or simply to give needed information? Should it lead to a master's degree, or is a less rigorous program more desirable?

Many engineers who have recently graduated from college will want a program leading to a master's degree. On the other hand, older engineers with many years of experience may not be interested in meeting the rigorous study and discipline required for academic credit. They prefer, instead, to assimilate the available knowledge and not bother with a thesis, examinations, and academic requirements.

Are the interests of these two groups compatible? Experience indicates that the best solution is a program tailored specifically to fit these different aims. Needs of the older students, and of those who want only the available knowledge, can best be met by a special program designed with these students in mind. Most instructors feel that to mix degree-seeking students with those "monitoring" the course without academic credit makes it difficult to maintain high academic standards. If qualified students are available, most educational institutions prefer to establish the program on the graduate level leading to a master's degree.

However, if the local situation is such that candidates desiring a degree must be merged with students not interested in academic credit, a skilled instructor can make the class profitable to both. In this case, establishment of minimum admission requirements, such as a bachelor's degree in engineering or its equivalent, is desirable. Often the phrase "or permission of the instructor" is listed among the admission requirements. This provision gives needed flexibility and assures that competent and able individuals will not be excluded.

The educational administrator will also inquire into the financial aspects of the program. To provide continuity of program, sequence of classes, and insure quality, the program must be financially sound. This is usually achieved by a combination of the following: 1. An ample number of tuition-paying students. 2. State and local financial support. 3. Industry support. 4. Some form of grant or endowment.

To summarize, an educational institution desiring to establish an engineering administration program, must establish affirmative answers to these questions:

1. Is there a substantial pool of engineers to draw from?
2. To what extent are the firms employing engineers interested?
3. Is the program financially sound?
4. Is it academically feasible for this institution to undertake it?
5. Are there adequate facilities?

Why Company Support?

Because it can expect these benefits—

- **better all-round planning**
- **increased production and profits**
- **improved morale**
- **better labor relations**

The company executive who may be planning a management course will want answers to certain key questions: What's the evidence that instruction in management is worthwhile? Will this program increase our profits? Will it increase production? Lower costs? Improve morale? The answers are obvious. Improved management will do all of these things.

The alert executive can establish the need for such a program by examining the quality of management in his own company. How does the company stand competitively? Is competition rough? Are company profits low? Are we setting the pace? Are we plagued with labor problems? Does our administrative team have a planned approach to problem solution? Are our engineering administrators utilizing commonly accepted tools of administration, such as production and planning control, quality control, cost accounting, methods analysis, performance measurement, layout planning, and inventory control? The decision to participate in a program of engineering administration often hinges on such factors.

Assuming that participation is desirable, what next? The responsible executive should then assure himself that the program offered is of high quality. The reputation of the educational institution and the qualifications of the staff that will govern the program are good indices.

How much will participation cost? Management training programs are expensive. Tuition, subsistence and salary while an employee attends an institution full time are considerable items. However, if the program is established locally, costs are

usually much lower, particularly if courses are made available in the late afternoon or evening.

The following information about the George Washington University program may be helpful. Many ambitious young engineering executives pay their own way. Practices of various private organizations and governmental agencies from which the students come vary greatly with regard to the payment of tuition. Some send their employees full time, paying salary and tuition. Others pay tuition only, and the employee takes the courses on his own time.

When the program was established in 1954, tuition was $500 for the MEA degree, which requires 30 semester hours of course work. It has been increased twice since then and is now $660 per student. Considering the benefits of the program, these tuition rates are nominal.

What's the Student's Viewpoint?

Before deciding, he should evaluate—

- potential value
- company attitude
- course quality and cost
- personal sacrifices

The engineer who is considering enrollment in an engineering administration program will want answers to these questions: What subject matter is covered? What will I get out of it? Why is it being offered? Who are the instructors? Are they good? When is it available? Where will it be offered? How much will it cost? What does my company think about it?

In addition to these questions, the prospective engineer-student will consider a number of other relevant things before registering. How will participation in this program affect his family? Community activities? Recreation? Social activities? Cultural activities? Professional activities?

If the program can be pursued full time during working hours, these personal considerations are not so pertinent. But if the program is held after company hours, such questions are painfully relevant, and the need for adjustments in family and professional affairs must be considered. Participation in a program that requires a minimum of one or two evenings a week (plus study time) for a period of three years is a major commitment.

How Are Subjects Selected?

To ground the student in these elements—

- management theory
- recent developments
- practical accounting
- standard managerial techniques

Obviously, prerequisites and subject matter for an engineering administration curriculum are of major importance. Prerequisites required will be governed by the level of the program. If the program leads to a Master's Degree, the candidate should have an academic background on which the Master's program can be built, usually through completion of certain undergraduate courses or their equivalent. In the George Washington University program, a basic knowledge of accounting, psychology, and statistics is required.

The general subject-matter content of the program may be selected to provide the student with any or all of the following elements:

1. A thorough grounding in basic theory as well as recent developments in management.
2. Review of results of recent research in the field of human relations.
3. Enough applied material in accounting to enable the executive to use accounting as a managerial tool.
4. An opportunity to learn the newer tech-

Table 1—Engineering Administration Course

Subjects	Semester Hours
Prerequisites	
Minimum, one course in each of the following:	
Accounting	3
Psychology	3
Statistics	3
Degree Courses	
1. *Management*	
Engineering administration*	6
Management of research & development**	3
Production, and maintenance management**	3
Managerial statistics and quality control**	3
2. *Human Relations*	
Problems in human relations	3
3. *Accounting*	
Managerial accounting	6
Budget preparation and control	3
Contract administration	3
4. *New Techniques in Management*	
Operations research*	3
Techniques of operations research	6
Problems in operations research	3
Economic analysis in engineering planning	3
Quantitative techniques of engineering administration	3
5. *Communication Skills*	
Communication of ideas	6
6. *Broadening or Cultural*	
Engineering geography	3
Engineer & society	3
Administration in government	3
Engineering law	3
7. *Technical Specialization*	
Courses in engineering science, physics or chemistry, as approved by adviser	3 to 6
8. *Application of Knowledge*	
Problems in engineering administration*	6

*18 hours must be in these subjects.
**Only one of these subjects is required.

niques of management, such as operations research, use of statistics as a tool of management, quality control.

5. The opportunity, if needed, to improve communication skills.

6. Broadening or cultural opportunities.

7. Opportunity to review new developments in the student's field of technical specialization.

8. Methods of applying knowledge acquired to the solution of a comprehensive engineering-administration problem.

Courses comprising the George Washington University program are grouped in Table 1 under the preceding general heads.

For a Master of Science degree in Engineering Administration, George Washington University requires 30 semester hours of graduate courses, including the solution of a comprehensive problem.

Who Are the Instructors?

Full-time or part-time, they must provide—

- **professional instruction**
- **leadership and supervision**
- **high academic standards**

Key to the success of any engineering administration course is the competence of faculty members. In the final analysis, leadership provided to the individual by the instructor determines whether or not the program is worth what it costs in time, money, and effort.

To successfully teach management to engineers, the instructor must have at least two qualifications: He must know his subject matter, and he must know how to teach. Instructors who are weak in either category are not suitable. To provide significant leadership, supervision, co-ordination, continuity, and to maintain high scholarly achievement, a central core of full-time faculty members is essential. This core must often be supplemented by a part-time staff. All faculty members, whether full time or part time, should evidence an appropriate balance among these personal qualifications:

1. Continuing academic and professional growth.

2. Ability to teach and inspire students in the development of a progressive professional career.

3. Industrial association and experience.

4. An interest in teaching and loyalty to the profession.

5. A record of achievement and productivity.

Program Scheduling

For best results—

- **offer prerequisites frequently**
- **repeat required courses yearly**
- **repeat popular electives**

Experience in conducting an engineering administration program reveals a number of guides that may be used in planning a schedule, providing there are enough students to require several sections of certain courses:

1. Prerequisite courses should be made available frequently—at least two each semester.

2. All required courses should be offered at least once during each academic year. There are usually a few full-time students who expect to complete the program in one year.

3. Popular elective courses may need to be repeated each year. Enrollment figures will indicate which ones they are.

4. A three-year cycle for elective courses should be established.

A master schedule for each semester is prepared by the Engineering Administration Staff of George Washington University. Courses are all 3 semester hours and meet one night per week for 2½ hours. Most students take two courses each semester and plan to complete the Master's Degree requirements of 30 semester hours in about three years. The arrangement whereby each class meets one night per week is well liked by the students since it saves considerable travel time and gives more time for assignment preparation and study at home.

All sections of each course, with the exception of the "Comprehensive Problem" meet at the same hour on the same evening of the week, facilitating the assignment of students to sections. One section of each class is taught at the University. Remaining sections are located either on the campus or in locations convenient for the students.

Counseling and Communication

To maintain good student relationships—

- **appoint faculty advisors**
- **facilitate personal contacts**
- **maintain mail and telephone contacts**
- **encourage company-university liaison**

Opportunity must be provided for students and members of the faculty to confer. This is especially important for part-time students who take courses after working hours. Because most of the students in an engineering administration course are mature men, they bring to the classroom a poise, an independence of thought and action, and an approach to problems that sets them apart from the younger students. They tend to be irked and frustrated by unexplained rules, regulations, procedures, delays, and seemingly arbitrary actions.

One way to solve the communications problem is to provide opportunities for faculty members and students to get together. For example, before enrollment of the full-time students, and certainly during the first semester for part-time students, the student and a faculty counselor should mutually decide on subjects which will make up the individual's curriculum. If wisely handled, this period of counseling can be used to explore the goals and ambitions of the student, and to deter-

mine the subject-matter areas which will be of most help.

Soon after this initial counseling period, a faculty adviser should be designated for each student. The responsibility of this adviser is to confer with the student about his studies, his comprehensive problem, clarify rules and regulations, initiate required changes in courses designated by the faculty counselors, and to generally express the University's interest in the student and his progress. Engineering executives and administrators often find it impossible to go to the University during working hours to confer with their advisers. However, they are often willing to make late afternoon or evening appointments. Willingness of faculty advisers to adjust their working hours to facilitate such contacts does much to develop mutual understanding and co-operation.

A little recognized problem which exists in after-hours, part-time graduate-study programs is maintaining communication between a university and its students. It is not easy to get information to everyone about matters that affect them. For example, assume that an instructor is ill and he cannot meet his class. For full-time students, this may be taken care of by a posted notice, perhaps on the classroom door. For an after-hours class, this unfortunately means that many students will make an unnecessary trip to the classroom.

Since many students meet their instructors only weekly, the usual forms of communication, such as class announcements or bulletin-board posters do not suffice. A new concept of communication is necessary. Policies, procedures, rules, regulations, course announcements, schedules, textbook lists, etc., must be put in clear concise form, published and mailed to all students concerned. Mailing and telephone lists are important and necessary to insure effective communication.

In the MEA program offered by George Washington University, the following means of communication are used:

1. Liaison representatives have been appointed to maintain contact between a number of federal agencies and the Engineering Administration staff of the University.

2. The School of Engineering has named two Navy members to its Committee on Graduate Studies. Representatives of the University are invited to participate in meetings of the Navy Educational Committee on Engineering Administration.

3. Training officers of federal agencies are used as schedule advisers for MEA students.

4. Policies, procedures, and information about courses and schedules are put in written form and disseminated to all students and training officers.

5. Informal conferences and telephone calls between University officers and training officers are held frequently.

6. Class announcements, bulletin-board postings, mailing lists and telephone lists are used. If an instructor is unable to meet his class at the time scheduled, students are notified by telephone, either personally or through the liaison representative.

Evaluating the Results

Although evidence is qualitative, it shows—

- **enrollment is booming**
- **employers are footing the bill**
- **management programs meet a need**

The purpose of an engineering administration program is to help engineers to become more proficient in the management of engineering and scientific programs, projects, tasks, or working groups. Experimental proof that participation in an engineering-administration program makes engineers more able managers than those who have never been exposed to such a program is not available. Attempts to statistically prove under controlled conditions that training programs produce significant changes in the persons trained have been disappointing. Even so, the indications of value are so convincing to trainees and management that educational and training programs are increasing rather than diminishing in number.

The available evidence, although incomplete and circumstantial, is that graduate education in engineering administration increases the competence of engineers and scientists in management. These facts about the program at George Washington University emphasize the point:

1. The growth in enrollment has been phenomenal. From an initial enrollment of 63 in the first class offered in the spring of 1953, the program now has 345 candidates for the Master's Degree. An enrollment of this size is evidence that the program is meeting a need.

2. The Navy Department has a highly regarded Senior Management Development Program. Since the establishment of the University program, more and more Senior Management Development trainees include the whole or a substantial part of the MEA program in their individually designed programs. Increasingly, the Navy bureaus subsidize the tuition cost of such MEA courses.

3. At the start of the program in 1953, no governmental agencies or private companies paid tuition for their employees. At the present time, tuition is paid all or in part by the Navy Department, the National Security Agency, six Navy bureaus and offices for civilians, and seven industrial companies in the Washington area.

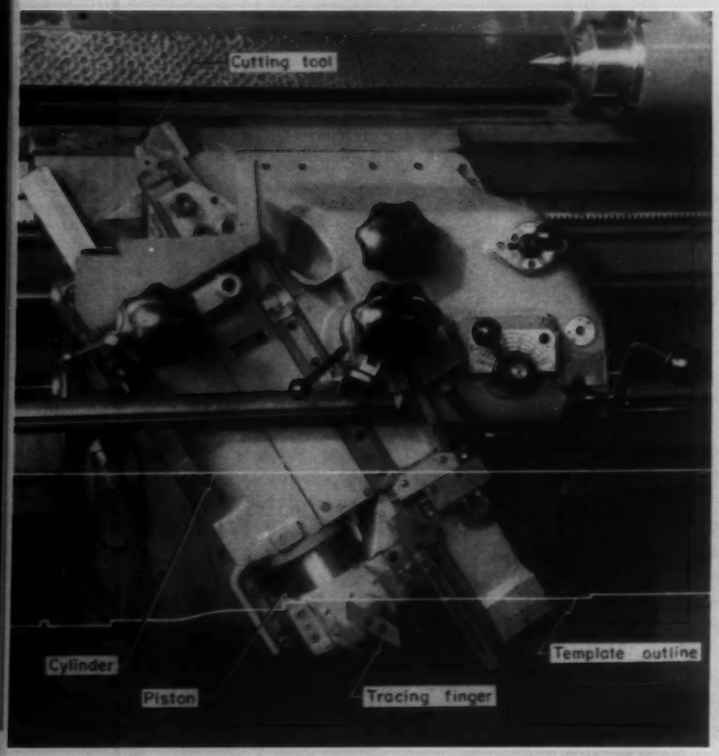
Such recognition by management is an indication that the program is meeting the purpose for which it was established. The dividends which result are well established.

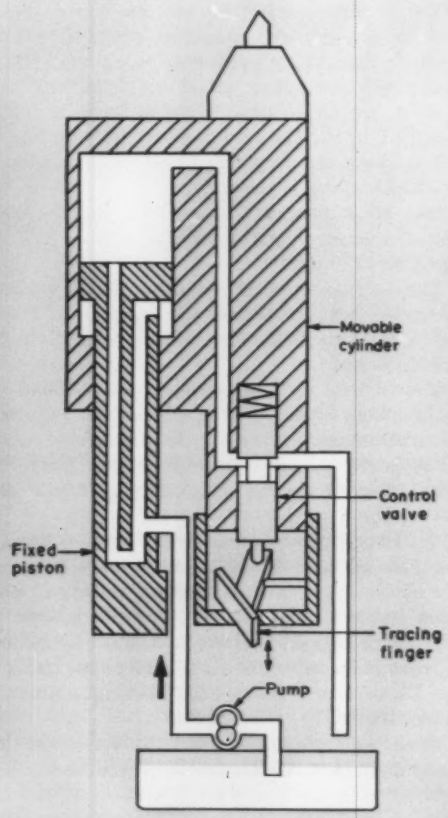
The necessary components are a sufficient supply of interested engineers, a co-operating university with adequate staff and facilities, and a company willing to support the program. Serving as catalyst to the project will be the strong motivating force supplied by persons or companies who recognize the need for improved management.

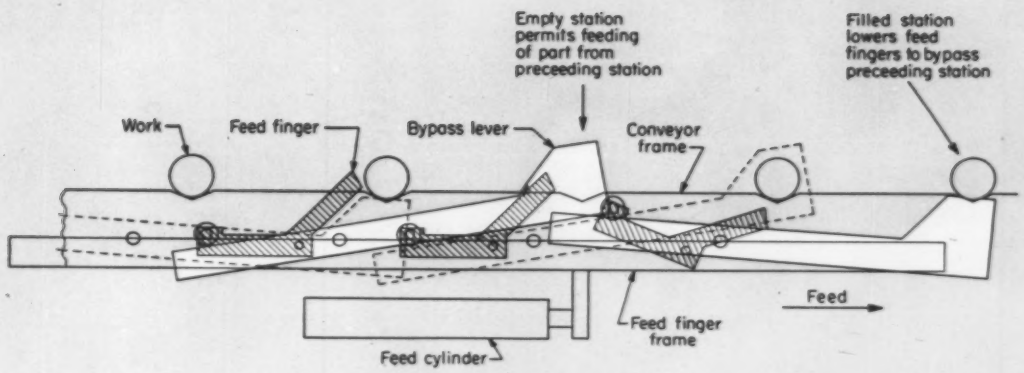
scanning the field for *ideas*

Fixed piston and moving cylinder are employed in a hydraulic servo-system to provide high magnification of actuating forces. In the design, developed by George Fischer Ltd. and New Britain-Gridley Machine Div. of the New Britain Machine Co. for a copy-lathe slide, the fixed piston has two separate passages leading from the pump into the cylinder. The passages open on opposite sides of the piston head. The cylinder, which is also the copying and tool-holding slide, moves up or down depending upon pressure differential in the chambers on the two sides of the piston head. The pressure in the chamber under the piston head is constant; the other chamber opens into a line leading past a control piston. Normally the aperture of the control piston permits fluid passage equal to input from the pump; the slide does not move.

Movement of the tracing finger as it follows the contour of a template increases or restricts the aperture at the control piston. If the aperture increases, the pressure above the piston head is reduced and the slide moves down, if the aperture is reduced, pressure is increased and the slide moves up.

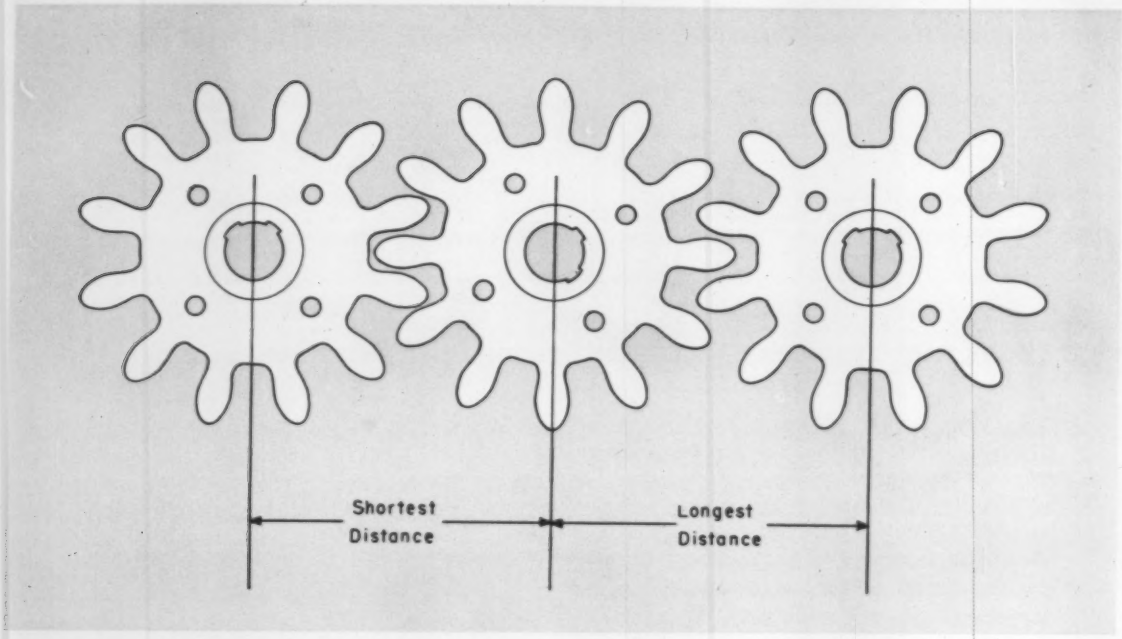


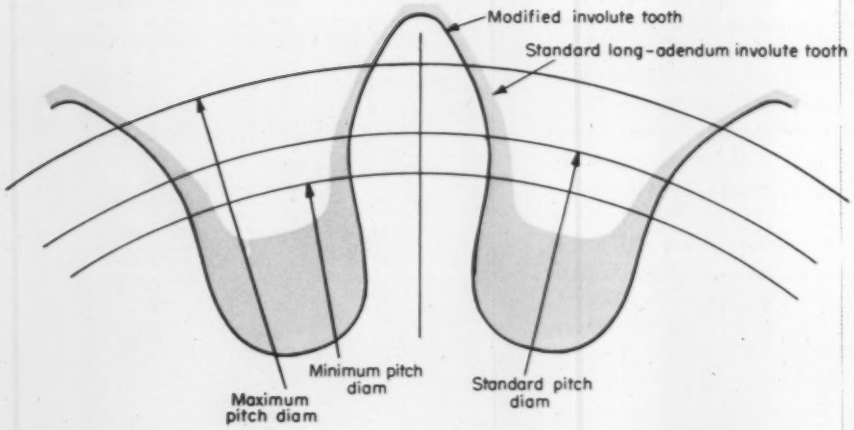




Demand control of power-conveyor operation for automatic processing is achieved with a novel detection and bypass lever system. The design provides disengagement of individual feeding devices if conveyor station is filled, yet permits movement of parts up to the last unfilled station. Developed by Machine Tool Div. of Wickes Corp. for an automated crankshaft-turning system, the conveyor carries parts between load and pick-off stations. To prevent idle machine time, the pick-off stations must be kept loaded and empty space between stations on the conveyor must be eliminated.

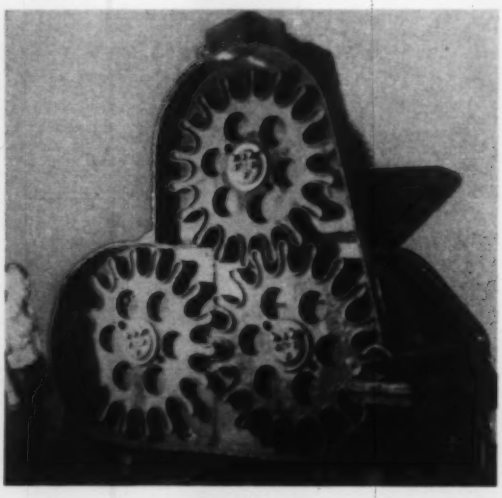
The design employs a hydraulically operated reciprocating frame that carries several pairs of feed fingers; each pair is hinged and has a roller at one end. Each station on the conveyor itself has a bypass lever with a part-detector blade at one end and a cam surface at the other. If the station is empty, the feed fingers are permitted to push a part into it as they move forward. If the station is loaded, the part-detector blade is depressed and the cam raised, lifting the roller on the feed fingers at the preceding station so that the part there is bypassed when the fingers move forward.



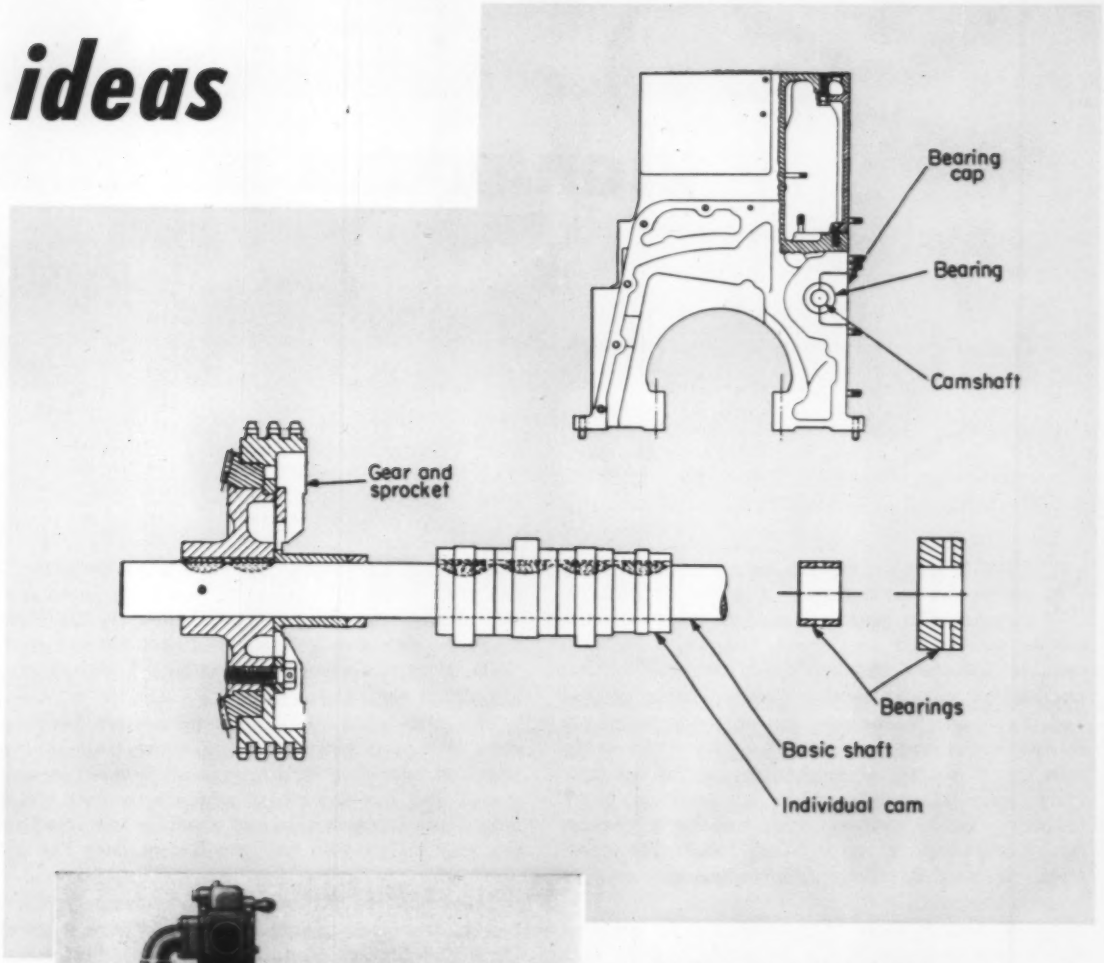


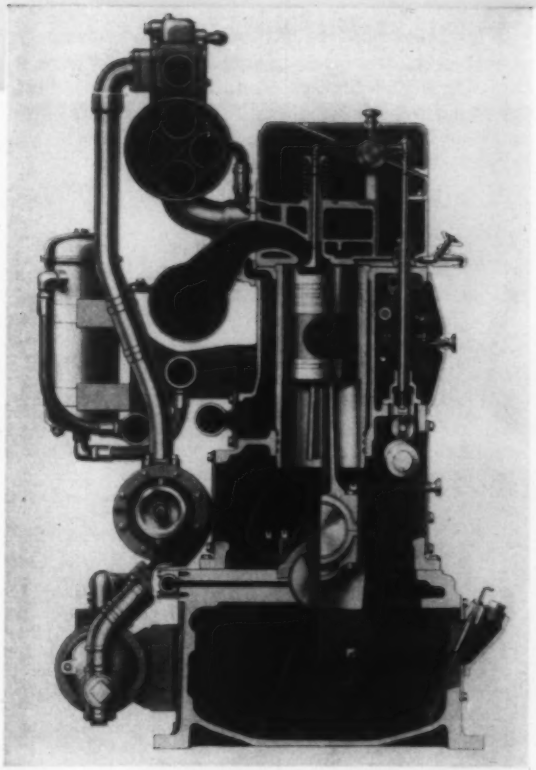
Varying gear center distances are accommodated by a modified involute-tooth form developed by Pioneer Engineering Div. of Poor & Co. Inc. for heavy-duty applications. The gears transmit power between crushing-machine rolls, which can be preset to various center distances to regulate crushing size and must open and close during operation to permit passing of noncrushable material.

The tooth form is basically involute in the addendum section but has considerable undercut in the dedendum portion to allow the gears to be set close together. This modified involute form allows greater variation of center distances than is possible with other tooth forms although backlash characteristics are not as favorable.



ideas





Modular camshaft design permits flexibility in matching overall system characteristics to varying assembly and application requirements. The construction simplifies assembly and disassembly of entire shaft, replacement of bearings, removal or replacement of individual cams, and design and specification of height, form, and angular location of individual cam throws.

Developed for use in diesel engines, the basic shaft is of constant diameter with a row of Woodruff key sprockets. Individual cams, gears, collars, and bearing bushings are added where required. Since each cam is a separate part, special cams can be readily added to the standard camshaft, or the cams arranged for individual application requirements. The entire camshaft assembly may be removed laterally from the cylinder-block casting by disassembly of the camshaft-bearing caps. White Diesel Engine Div. of White Motor Co. developed the design.

How to use

HIGH-SPEED MOTION-

. . . for analyzing and designing high-

STUDYING the dynamic behavior of moving parts and mechanisms in machines has always been a real challenge to designers. Often as not, until recent years, the diagnostic procedures followed in the kinematic and kinetic analysis of parts in motion were laborious at best and the results unreliable. But with the many excellent high-speed, motion-picture cameras available today, secrets of mechanism motion are now often readily revealed. New advances in high-intensity light sources and timer-synchronizer equipment simplify the lighting and timing problems, as well as film-speed limitations, encountered in the past.

As a design tool, high-speed movie cameras slow down motions which normally appear as a blur to a slow crawl. The behavior of a particular mechanism or part during an entire operation or at any desired instant is clearly visible. Equally important, this design-analysis technique allows the slowed-down operation to be viewed simultaneously by many observers, and reviewed in its entirety or in part as often as desired. It enables the engineer to study dynamic forces in action and to observe the effects of inertia of masses of machinery—for example, the effects of improperly designed cams in generating motions. Intelligent appraisal of the information provided by the high-speed camera can lead the engineer toward solutions he might never have visualized without the aid of this engineering tool.

The high-speed motion-picture camera thus assists design engineers in the same way that a televised operation aids groups of prospective surgeons, and has the added advantages that it not only slows down motion and provides unlimited repeatability, but also can greatly magnify the operation.

These cameras have proved to be extremely valuable in the electron-tube industry, where a great variety of high-speed automatic and semiautomatic machines are employed for the fabrication and assembly to dedicate and complex tube components.

▶ Time Magnification

The RCA Electron Tube Div. has had excellent success with a camera which takes pictures at speeds up to 3200 frames per sec. This figure represents a time magnification of 200 when the film

Fig. 1—Typical lighting and camera set-up for taking high-speed motion pictures. The camera is the Kodak "High-Speed." Camera speed is continuously adjustable from 750 to 3000 frames per sec. The auxiliary timer-synchronizer unit designed by RCA is shown behind the operator.

PICTURE CAMERAS

speed mechanisms

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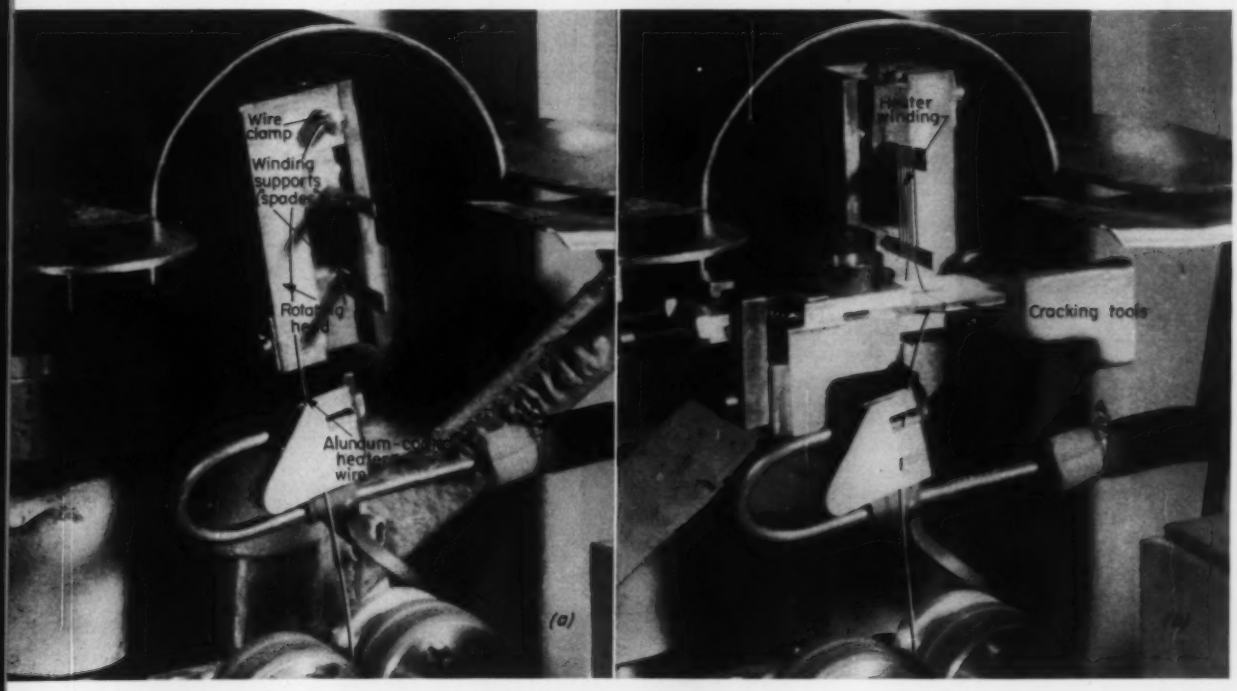
is projected at the normal rate of 16 frames per sec.

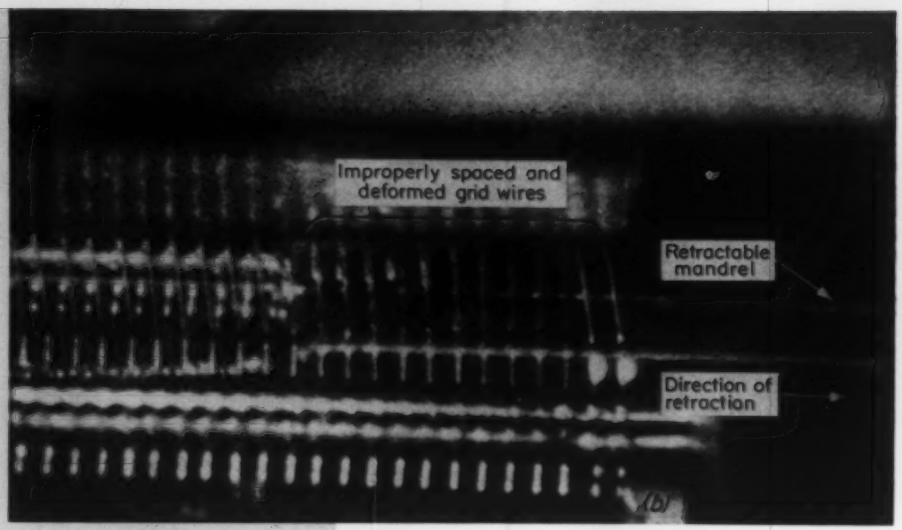
What does a time magnification of 200 mean? It means that an action which actually takes place in 1 sec will appear to take place over a period of 3 minutes and 20 seconds. It means that the behavior of a jet plane crashing through the sound barrier can be seen as clearly as if the plane were traveling at a speed of approximately 3 mph. It means that a shaft turning at a speed of 400 rpm appears to make 1 revolution in approximately 30 sec.

▶ Camera Operation

The camera in Fig. 1 is a 16-mm unit which operates on 115 volts ac or dc. It takes a 100-ft roll of film containing 4000 frames, and is provided with a rheostat speed control. A variety of lenses are available for this camera, including a

Fig. 2—"Spade" winder mechanism at the start of the winding operation, *a*, and at the end of the winding operation, *b*, showing head containing "cracking" and cutoff tools in operating position. Camera speed—3000 frames per sec; lens—63-mm, f:3.5; lighting—four 750-w photoflood lamps; distance, lens to subject—12 in.





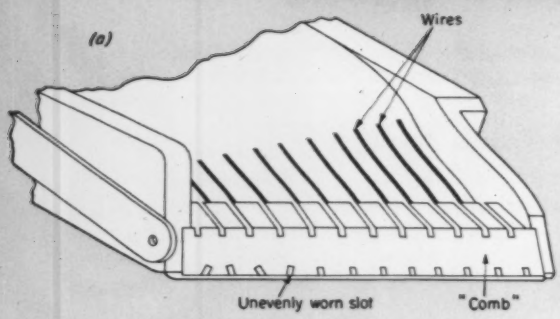


Fig. 3—Comb of the automatic welded-grid machine, *a*, showing improperly cut teeth responsible for uneven spacing of the grid wires. In *b* is a frame from high-speed film of grid-assembly operation, showing deformation caused by withdrawal of mandrel. Camera speed—1700 frames per sec; lens—102-mm, f:5.6; lighting—four 750-w photoflood lamps; distance, lens to subject—16 in.

120-mm, f:2.7 lens which provides a large magnification of the objects being photographed.

At a speed of 3000 frames per sec the entire reel flicks past the gate in approximately 1½ sec. Although an automatic shut-off switch stops the camera motor instantly when the film ends, the last 3 or 4 ft of film are literally shattered.

When the camera is set for a speed of 3000 frames per sec, the film reaches 80 per cent of this speed within 1/3 sec (approximately 25 ft), and accelerates to full speed gradually over the remainder of the run. Since the first 25 ft of film passes through the gate much more slowly than the remainder, the beginning of the film will be overexposed. The camera is, however, provided with a built-in synchronization switch which can be used to control external lighting so that actual photography does not begin until the film has reached a predetermined speed.

The camera also contains a timing lamp which flashes at intervals of 1/120 sec when the camera is operated on 60 cps ac, and provides visible markers along the edge of the film strip. At 3000 frames/sec, markers are 25 frames apart.

Timing and Synchronization

To eliminate guesswork and human error in the use of the camera, the Equipment-Development Activity at the RCA Harrison plant developed a special timer-synchronizer unit which automatically triggers the camera at the proper moment in the machine operating cycle. This instrument is shown behind the operator in Fig. 1. The camera is plugged into this timer-synchronizer unit and is not touched by the operator until the film has been run.

The timer is triggered by a precision snap-action switch which is installed, by the photographer, in the machine so that it is actuated at the desired point in the operating cycle. When this switch is tripped, the timer assumes full command. It turns on a cluster of four 750-watt photoflood lamps, waits for the light to attain full intensity, and then starts the camera. When the roll of film has been run, the camera is automatically shut off, the lights go out, and the operation is over.

Selecting Film Speed

An important consideration in the use of the high-speed camera is determination of the film speed which will best provide the desired information when the film is projected. Although the designer might think that the higher the speed the better, excessive speed may make it difficult to isolate visually the action of maximum interest. The *optimum frame frequency* (frames per sec) equals 40 times the *speed of the subject* (in. per sec) divided by the *total width of the lens field* (in.). The denominator can be obtained from a table for a lens of a given focal length.

Example: Assume that the speed of subject = 100 ft per sec or 1200 in. per sec and the width of lens field = 15 in. From these data optimum frame frequency = 40(1200)/15 = 3200 frames per sec.

With proper techniques, velocities and accelerations can be accurately measured. For example, a proportional correlation between the distance traveled by the object in motion and the number of

frames required to photograph that motion can be obtained by photographing the object against a suitable scale. The picture frequency may be accurately determined by use of the built-in timing lamp previously referred to.

Application in Design

A number of studies using the high-speed camera have been made by the Harrison Equipment-Development Activity. The most dramatic of these studies from the viewpoint of the engineer trying to solve a particular problem were the following:

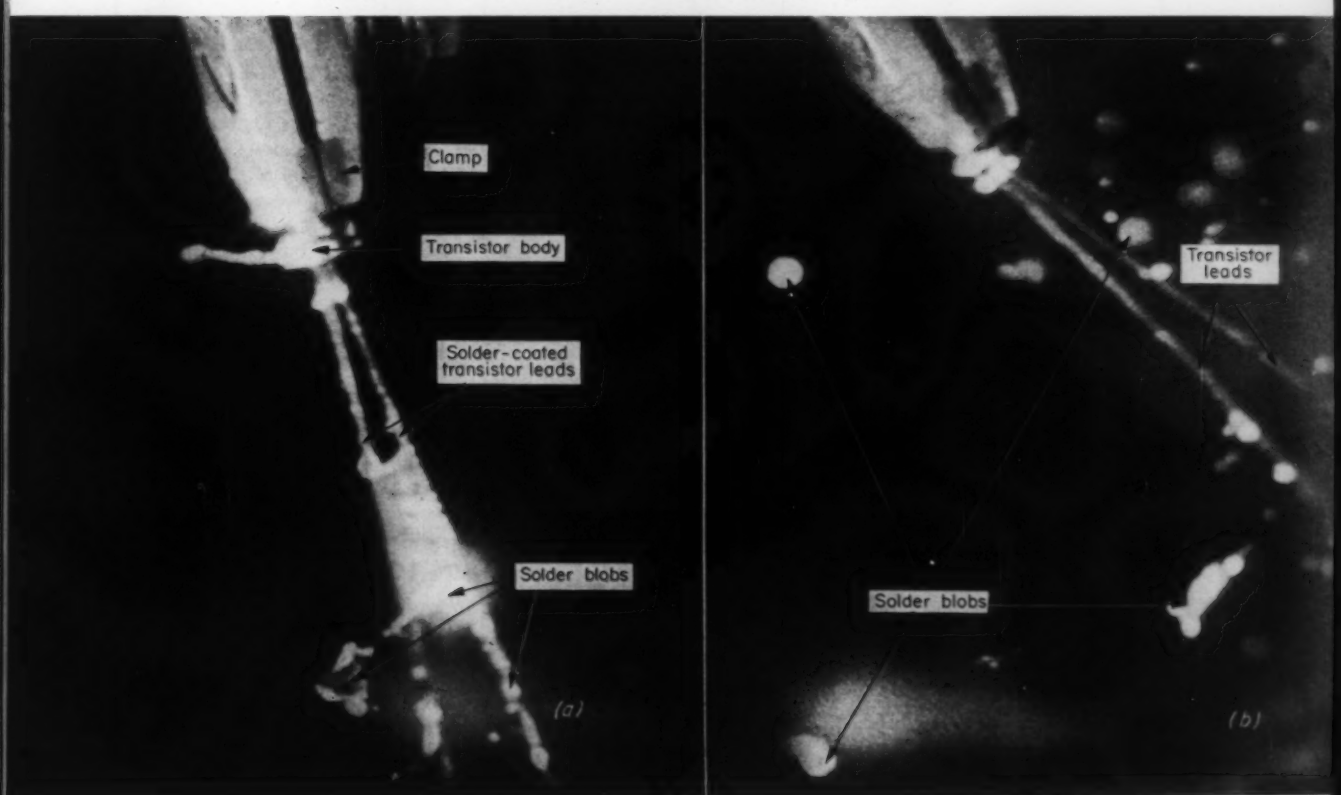
A stem machine, which performs a series of automatic-assembly operations necessary to form the stem of an electron tube, was subjected to a kinematic analysis with a view toward increasing its rate of production by increasing its indexing speed. To determine the performance during the indexing operation a carpenter's flexible-steel tape was attached to the periphery of the horizontal steel turret so that it would appear in the film. The film showed that the turret decelerated properly up to a point near the end of the indexing cycle. At that time it was evident that the turret actually stopped, then moved forward slightly, stopped again, and then bounced back about 1/16 in.

Obviously, the design of the commercial roller-gear indexing unit was faulty in that the rollers in the drive mechanism lost contact with the indexing cam near the end of the cycle. As a result of these findings, the manufacturer of the roller-gear drive was asked to redesign the indexing cam.

A "spade winder" is a machine used to form cathode heaters of the "folded" type to the desired configurations. Its name is derived from the flat blades or "spades" around which the alundum-coated heater wire is wound during the forming operation, Fig. 2*a*. The free end of the wire is gripped by a clamp set into the head containing the "spades." The head revolves, pulling the wire around the spades until the required number of turns have been formed. As the head stops, an arm carrying "cracking" and cutoff tools swings into the position shown in Fig. 2*b*. These tools then strike the ends of the wire, removing the alundum coating for the desired distance and cutting the ends to the desired length. The action of these tools is much too fast to see.

Irregularity in the operation of the spade-winder

Fig. 4—Frames from high-speed film photographing lead-wire tinning machine operation. Blobs of excess solder thrown off at start of snapping motion are shown in *a;* thrown-off solder relanding on lead wires after snapping motion has stopped is shown in *b*. Camera speed—2000 frames per sec; lens—63-mm, f:3.0; lighting—four 750-w photofloods; distance, lens to subject—24 in.



led to a decision to undertake a redesign. To obtain the necessary information, a series of high-speed films was made. These films showed: 1. Excessive slack in the wire during the first revolution of the head. 2. Sidewise vibration of the "spades" supporting the winding. 3. Uneven stopping of the head. 4. Breakoff of alundum chips at the apices of the folds, and the paths followed by these chips after breakoff.

The excessive slack showed that the wire-tensioning device was not properly designed for the speeds at which the spade winder was required to operate. The vibration of the winding-support blades was caused by lack of rigidity in the head. The operating cam design required redesign to provide smoother movement and stopping of the head. Redesign of the exhaust system was also required to assure complete removal of the alundum chips broken off during the winding operation.

An automatic welded-grid machine is used to produce parallel-wire grids for electron tubes. The required number of lateral wires are drawn through a "comb," Fig. 3*a*, and welded to two side rods. During the drawing operation a retractable mandrel is inserted between the side rods to give the lateral wires an elliptical contour. Uneven spacing of the lateral grid wires prompted an investigation which led to taking high-speed motion pictures. From the films, two reasons for the difficulty were immediately apparent: 1. Some of the slots in the comb through which the lateral wires are threaded before welding to the side rods were improperly cut or unevenly spaced, causing the wires to be improperly spaced in relation to each other. 2. When the mandrel withdrew after the lateral wires were welded to the side rods, it dragged some of the lateral wires with it, deforming them slightly and changing their spacing Fig. 3*b*. The problem of spacing was solved by fabrication of a new comb. Problem of the mandrel is undergoing further study.

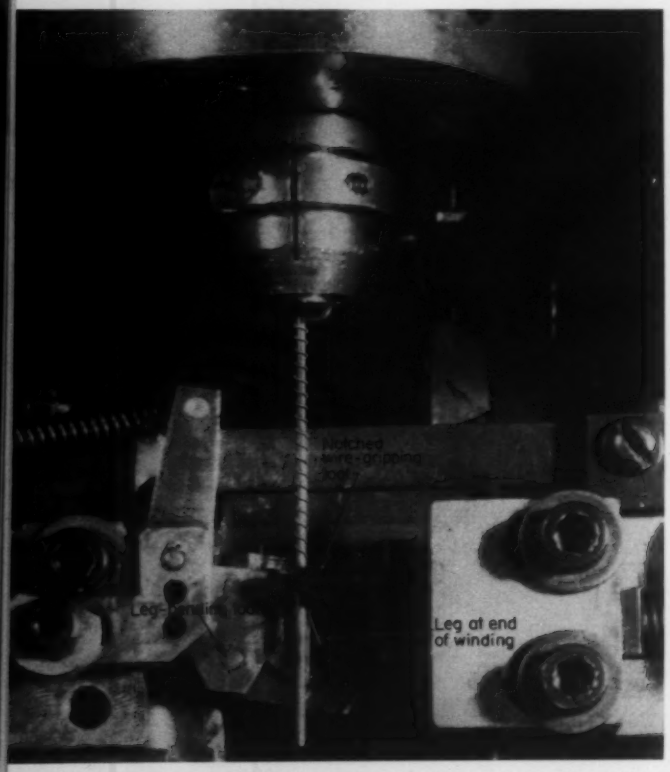


Fig. 5—Head of heater-spacer coil-winding machine. Pictures show why tails on coils were not consistently formed at the same angle. Camera speed—1200 frames per sec; lens—102-mm, f:4.5; lighting—four 750-w photoflood lamps; distance, lens to subject—12 in.

Transistor lead-wire tinning machine simulates the manual operation in which the lead wires are dipped into solder and then shaken with a snapping motion to throw off excess solder.

The leads of the machine product, however, retained tiny globules of solder and, consequently, did not have the smooth appearance desired in a good quality product. To everyone's amazement, films taken by the high-speed camera revealed that the excess solder left the leads in blobs at the *beginning* of the snapping stroke, Fig. 4*a*, instead of at the *end*, where the transistor is stopped with a shock. These films also disclosed that the cast-off blobs of solder, because of their momentum, caught up with the stopped leads and sprayed them with tiny globules, Fig. 4*b*.

As a result of this study the snapping motion was modified and the condition remedied.

A heater-spacer coil-winding machine winds tungsten wire—a wire with a nasty temperament—into small coils, Fig. 5. These coils are subsequently coated with insulating material and used to prevent contact between unipotential cathodes and their internal heaters. The machine also forms a leg or "tail" at one end of the coil, which provides a means for gripping the coil during the cataphoretic coating process. The machine, however, failed to form the tails consistently to the same angle.

The high-speed camera showed that the notched tool used to grip and bend the tail permitted the tail to escape from its notch before the bend was completed.

This problem was solved by a redesign of the bending tool to assure retention of the tail throughout the bending operation.

Summary Remarks

This article shows the design-analysis potential of a very useful tool. With the ready availability of many good high-speed cameras, the design engineer is in a position similar to that of the doctor who just realized the value of an available instrument—the microscope. Both devices make it possible to probe the unknown—one by magnifying dimensions alone, the other by magnifying time and dimensions.

A Progress Report On

Titanium-Alloy Fasteners

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Extensive research and development effort has converted titanium alloys into acceptable high-quality fastener materials. In addition to general improvements in the materials themselves over the past few years, major advances in processing know-how have overcome some of early manufacturing problems, such as heat-treating and forming techniques. Here is a complete report on the present status of titanium-alloy fastener development, with emphasis on the significant findings influencing design evaluation.

Data in this report are based on an extensive testing program of titanium-alloy fasteners and parts conducted by Northrop Aircraft Inc. Preliminary results of this program were presented in an earlier report (August, 1955, *Machine Design*, Page 169).

RESEARCH and development efforts on titanium-alloy fasteners had humble beginnings. With little knowledge of metallurgical and processing properties, a project was undertaken at Northrop to produce and test AN3 and AN509 titanium-alloy fasteners. Material selected initially was an aluminum-manganese titanium alloy (4Al, 4Mn).

On the surface these early test fasteners looked satisfactory. Statically, they were acceptable, but some were almost as brittle as glass. Fatigue tests, so important in predicting the behavior of fasteners under aerodynamic loads, revealed almost completely erratic patterns that were quite discouraging, Fig. 1. It was soon apparent from these early test results that general improvements in materials and manufacturing techniques were necessary.

The next step involved metallurgical studies of heat treatments. Aims of this investigation were to obtain uniformity in material strength properties, both statically and dynamically, and to develop high strength levels through thermal processing techniques. In these tests, titanium-alloy fasteners were subjected to four different heat-treatment concepts. Although static properties resulting from all the heat-treatment concepts

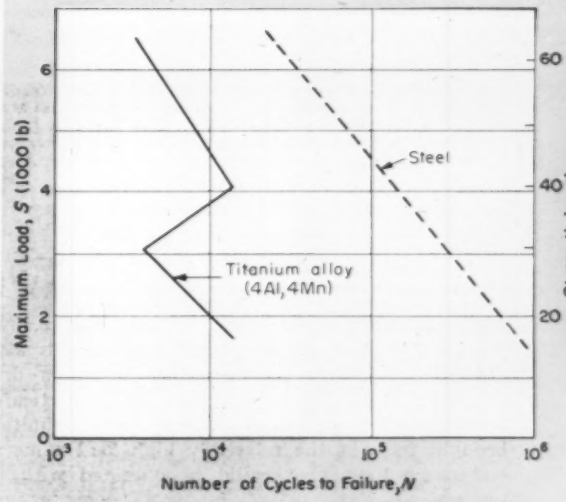
Maximum Load, S (1000 lb)
Strength Level (per cent of minimum ultimate tensile strength)
Steel
Titanium alloy (4Al, 4Mn)
Number of Cycles to Failure, N

Fig. 1—Comparison of fatigue behavior of early titanium-alloy test fasteners with their steel counterparts. Test results such as this indicated need for general improvements in fastener materials and manufacturing techniques.

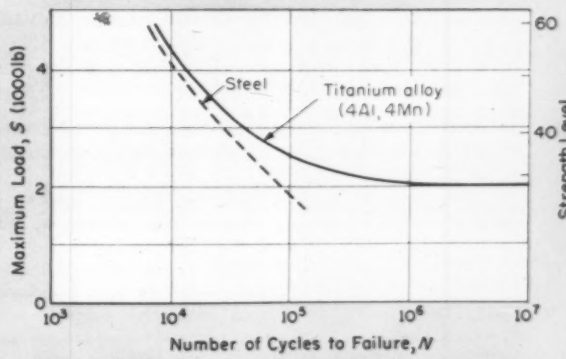
Maximum Load, S (1000 lb)
Strength Level (per cent of minimum ultimate tensile strength)
Steel
Titanium alloy (4Al, 4Mn)
Number of Cycles to Failure, N

Fig. 2—Comparison of fatigue behavior of properly heat-treated titanium-alloy fasteners with their steel counterparts. Plots are based on ¼-in. diam bolts of NAS464 configuration.

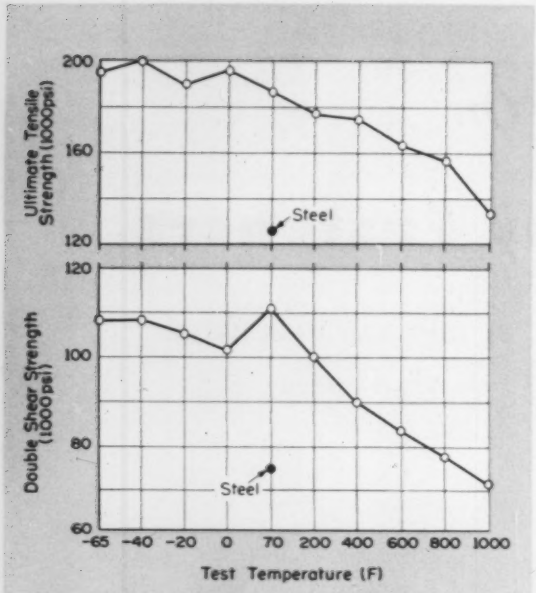

Fig. 3—Static mechanical properties of 6Al, 4V titanium-alloy fasteners showing plots for ultimate tensile strength and double shear strength. Fasteners are NAS223-25 configuration. Point plots are based on average for five test specimens. Minimum requirements for comparable steel fasteners are shown for reference.

were quite acceptable, only one heat-treatment concept exhibited satisfactory fatigue results. In Fig. 2, the *S-N* curves of properly heat-treated NAS464, C-130AM titanium-alloy fasteners dramatically emphasize the comparative properties of titanium alloy and steel. These tests definitely brought to light the relatively high load value at endurance limit that could be obtained with titanium.

Among other aspects to be considered in substituting titanium fasteners for steel was the question of how titanium materials would galvanically affect, or be affected by, conventional structural aircraft materials such as aluminum, magnesium, and steel. To find the answers, a thorough program was conducted to determine the galvanic characteristics of titanium-alloy fasteners.

Results and recommendations of this program are:

1. Titanium-alloy bolts are essentially unaffected by galvanic activity when coupled with common aircraft structural materials.

2. Titanium-alloy bolt cathodes do not appear to stimulate galvanic corrosion in base metals at any greater rate than do alloy-steel bolt cathodes.

3. Titanium-alloy fasteners may be substituted for alloy-steel fasteners without entailing any unreasonably complicated or critical protective systems with one exception: Assemblies utilizing magnesium and titanium in direct contact are not recommended.

4. The same corrosion-protection precautions and practices are recommended for assemblies using titanium fasteners as are normally considered adequate and specified for assemblies utilizing stainless-steel fasteners. Titanium alloys should be considered corrosion resistant. No finishing is necessary except for dissimilar metal contacts.

Air Force Program: This early project was followed by a five-phase program of titanium-fastener development under contract with the Air Material Command. The first four phases of this program have now been completed and the fifth is well underway.

The first phase constituted an investigation and survey of the airframe and jet-engine industries to determine anticipated quantity and configuration usage. It was found that if all fasteners made from high-density materials utilized annually in the aircraft and aircraft-engine industries were converted directly to titanium approximately 7 million lb (3500 tons) of titanium would be utilized at a weight saving of approximately 3 million lb.

In the second phase, the fasteners were all AN and NAS shear types, consisting of hexagonal,

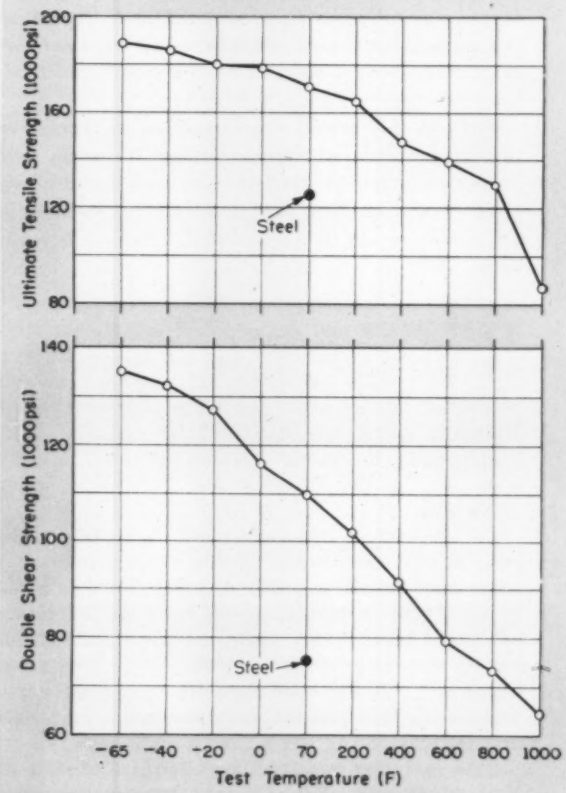

Fig. 4—Static mechanical properties of 4 Al, 4Mn titanium-alloy fasteners showing plots for ultimate tensile strength and double shear strength. Fasteners are AN4-14A configuration. Point plots are based on average for five test specimens. Minimum requirements for comparable steel fasteners are shown for reference.

countersunk, and brazier-head threaded fasteners, Huck stumps, and Hi-Shear rivets. Both 125,000 and 160,000-psi minimum ultimate strength configurations were represented. Two available production alloys were analyzed and selected for this program: 4Al, 4 Mn; 6 Al, 4V. It is believed that this was the first attempt to produce fasteners from the aluminum-vanadium alloy. From preliminary investigations, increased strengths, more uniform heat treatment, and higher operating temperatures were anticipated through the use of this material.

Since all of the fastener producers participating in the program did not possess the same degree of titanium-fastener manufacturing experience, a procurement specification (Northrop NAI-159) was developed. It clearly defined the product and provided specific heat-treatment recommendations for producing fasteners with satisfactory static and dynamic characteristics. This specification completely described a number of items and processes which are critical in the manufacture of quality titanium fasteners. These items include:

1. Material composition limits, including a maximum for hydrogen.
2. Minimum mechanical-property limits for each alloy; the material must be capable of meeting these requirements after heat treatment.
3. Maximum surface roughness for fastener stock.
4. Increased minimum and maximum head-to-shank fillet radii.
5. Surface-finish requirements for finished fasteners.
6. Thread form and dimensions (Specification MIL-B-7838A).
7. Cold-working requirement for head-to-shank fillets of all titanium fasteners.
8. Recommended heat treatments to produce the required fastener mechanical properties.
9. Fatigue requirements for each size and configuration.

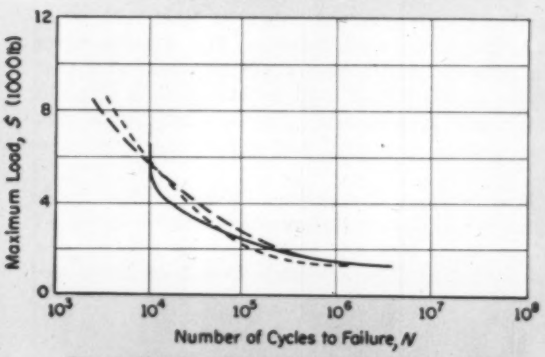

Fig. 5—Results of co-ordinated checkout of tension-tension fatigue testing specification developed for titanium fastener research program. Plots represent data from three separate test facilities, using three different fatigue machines. Steel fasteners of NAS336-A15 configuration were employed for the checkout.

Test Results: Static test results obtained in the third phase of this program proved that all properly manufactured titanium-alloy fasteners surpassed the static strength requirements of their steel counterparts in all sizes. Steel would require a minimum ultimate tensile of 275,000 psi to equal titanium's room temperature values.

Better static room and elevated-temperature properties were obtained in fasteners made from the aluminum-vanadium alloy than from the aluminum-manganese alloy. Some of the aluminum-vanadium fasteners provide an average ultimate tensile strength of approximately 132,000 psi at a soaking temperature of 1000 F. Fig. 3 summarizes average static-shear and ultimate-tensile strength at all test temperatures for NAS223-25 fasteners made from the aluminum-vanadium titanium alloy. Minimum requirements for steel are plotted for reference purpose. A similar summary of average static-shear and ultimate-tensile strength values for AN4-14A fasteners made from the aluminum-manganese titanium alloy appears in Fig. 4. Fig. 3 and 4 emphasize the improvement that both titanium alloys have achieved through proper heat treatment and fabrication processes.

Included in the static testing evaluation was torque-stress data obtained with nonlubricated titanium fasteners using standard steel nuts. The results of these tests essentially indicated that the torque requirements for titanium are equivalent to steel.

Long-time, elevated-temperature relaxation tests

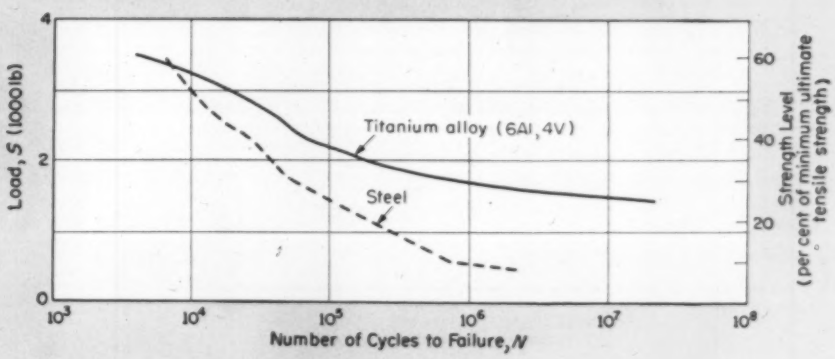

Fig. 6 — Typical fatigue-strength curves for comparable fasteners of aluminum-vanadium titanium alloy and steel. Plots are based on fasteners of NAS464 configuration.

are now being performed on specimens of both titanium alloys which have been heat treated according to Northrop specification NAI-159B for the titanium-alloy fasteners. A tensile load of 95,000 psi is maintained at all times during the tests. Results so far indicate that creep and relaxation are of little significance in either alloy at temperatures up to and including 400 F. Current relaxation tests are being conducted at temperatures ranging from −65 to +1000 F in both alloys.

Fatigue Behavior: A study of fatigue-test procedures disclosed a series of variables that could cause many inconsistencies in test results. Thus, a standardized test method was imperative for the success of the program. Through a series of conferences with specialists in this field, a specification was drafted for standardized tension-tension fatigue testing. This tentative specification, NAI-160, was proved out through a co-ordinated test checkout in three independent test facilities, utilizing three different fatigue machines.

Results of this co-ordinated test checkout are summarized in Fig. 5. The plot shows the excellent correlation of data that was obtained to prove that standardized test results could be achieved. This specification is now being adopted by ARTC and NASC as an industry and Government standard.

The fatigue-testing project is comprised of room-temperature fatigue tests on identical titanium-alloy and steel fasteners in each size and configuration, totaling some 650 fasteners. Fatigue tests were conducted on three specimens of each material at five stress levels. The highest stress level was 60 per cent of the minimum ultimate material strength, and the individual threaded fastener load was based upon the effective area. Nonthreaded fastener loads were based upon the recommended design load for the fastener being tested. Test stress levels ranged from 60 per cent down to endurance limit in increments of approximately 10 per cent. The stress ratio was $R = 0.1$.

Typical S-N curves for aluminum-vanadium titanium alloy and steel fasteners in the NAS464-4A-17 configuration are shown in Fig. 6. The fatigue plots shown in Fig. 6 and 7 express the outstanding endurance-limit properties of titanium as compared to steel. At the higher stress levels, fatigue strengths of titanium fasteners, on a size-for-size basis, were comparable to the 160,000 psi minimum steel fasteners and superior to steel in the 125,000 psi minimum range. The fatigue properties of both titanium alloys were comparable.

Dynamic Advantages: From analyses of the endurance-limit capabilities of titanium, the term "dynamic advantage" was evolved for the purpose of comparing titanium with steel on the basis of fatigue strength and density. First, the dynamic value of each material at any given number of cycles is determined by dividing the actual fastener load in lb by the material density. Second, the dynamic value of titanium is divided by the dynamic value of steel. This results in the "dynamic advantage ratio"; steel always being equal to one.

Under standardized test conditions the titanium fastener (NAS223-25) was 3.30 times dynamically superior to its steel counterpart. A study of comparative weight relationship between the two fasteners at 100,000 cycles indicates that the steel fasteners required to dynamically equal its counterpart in titanium would weigh at least 6.85 times that of the titanium fastener. Fig. 8 summarizes the dynamic advantage of 300 titanium-alloy fasteners versus 300 of their counterparts in steel. In structural applications, titanium will effectively surpass steel in fatigue and weight characteristics.

Metallurgical Evaluation: None of the third-phase series of test fasteners examined were found to be metallurgically unsound. In general, the grain flow in fasteners made from both alloys ap-

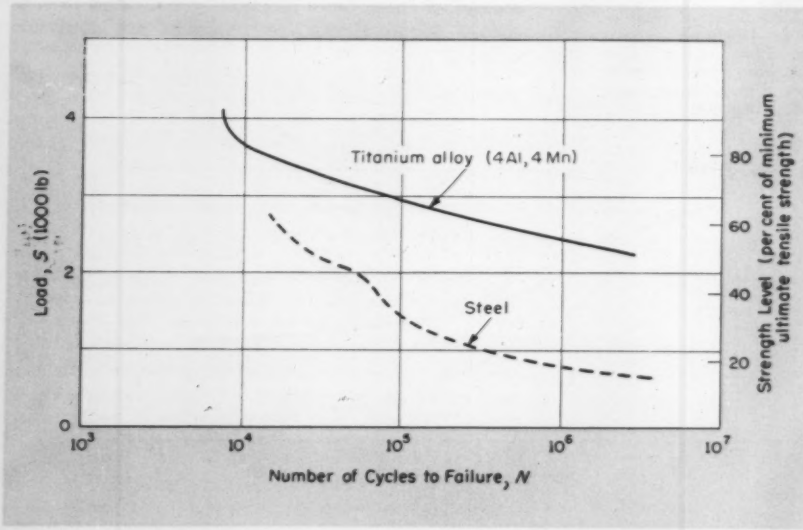

Fig. 7 — Typical fatigue-strength curves for comparable fasteners of aluminum-manganese titanium alloy and steel. Plots are based on fasteners of AN4-14A type.

peared to be satisfactory. The grain size is almost always smaller in fasteners made from the aluminum-vanadium material than in the aluminum-manganese alloy. However, tests results indicated no distinguishable difference in mechanical properties due to grain size. The few titanium fasteners which failed to meet the minimum requirements of their nontitanium counterparts exhibited definite evidence of having undergone improper processing. No undue failures could be attributed to faulty materials.

Producibility Determinations: From the test results, several conclusions can be drawn on producibility aspects.

1. Titanium-alloy fasteners in the shear-type configurations (second phase) which are functionally equal or superior to their steel counterparts can be produced.

2. Comparative dynamic and static tests of properly processed titanium fasteners made from the 4 Al, 4 Mn and 6 Al, 4 V alloys can be summarized as follows:

Fatigue values are approximately equal for both alloys with a higher load value at endurance limit for the aluminum-vanadium alloy fasteners.

At 1000 F soak temperature, ultimate tensile strengths of the aluminum-vanadium fasteners ranged up to 35 per cent above the aluminum-manganese fasteners. At 70 F, a minimum average ultimate tensile value of 160,000 psi can be obtained with aluminum-manganese alloy fasteners. For the aluminum-vanadium alloy at this temperature, a value of 180,000 psi is possible. At −65 F, static ultimate tensile values are approximately equal for both alloys.

Static shear values for both alloys are approximately equivalent at 70 F and elevated temperatures. At subatmospheric temperatures, aluminum-manganese alloy fasteners exhibited increased shear strength.

3. Complete advantage of the high strength-to-weight ratio of titanium-alloy fasteners cannot be realized unless the fasteners have been fully and properly heat treated (soaked, quenched, and aged). Annealing and/or stress relief alone is not sufficient heat treatment to consistently obtain the optimum properties in titanium fasteners.

4. Torque-stress test values for titanium-alloy fasteners are comparable to values for their steel counterparts.

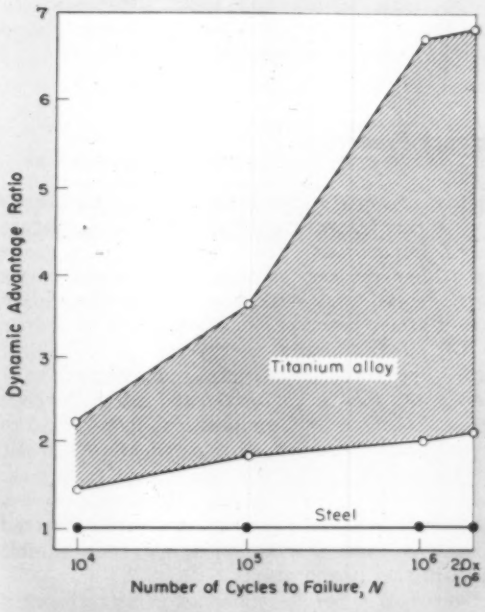

Fig. 8—Dynamic advantage chart for comparison of titanium-alloy and steel fasteners on the basis of fatigue strength and density. Plots represent the summary of results obtained with 300 fasteners of each material. For steel, advantage ratio = 1.

In the third-phase test series, a question arose concerning the possible adverse effect on titanium-alloy fasteners of subjecting them to temperatures exceeding 300 F subsequent to final aging treatment. For want of a better term, these effects were called "embrittlement." Evidence of this condition had been found by others.

A minimum number of tests were performed on titanium fasteners which had been subjected to a temperature of 700 F for 2 hr. In the specimens made from the aluminum-manganese alloy, there was a decrease of approximately 25 per cent in fatigue strength. No conclusive evidence was found, however, which indicated that the aluminum-vanadium alloy fasteners were susceptible to such embrittlement. As a result of these tests, a program for further investigation of this problem was proposed to the Air Force. Action is expected in the near future on this important research.

Final Phase: The fifth and final phase of this program constitutes the production, testing and producibility evaluation of fastener configurations having high-property requirements. No production difficulties of any greater magnitude than those encountered in the other phases are anticipated. In fact, some of these fifth-phase titanium-alloy fastener configurations are already being utilized in certain advanced airframe designs.

Future Requirements: The major obstacle now being faced in fasteners development is the heat barrier. Greatest immediate need is for titanium fastener alloys capable of withstanding service temperatures in the 1000 to 2000 F range. Operational aspects of air vehicles now in the design stage demand this development, and the high melting temperature of titanium leads to the belief that there must be a way of producing titanium alloys which will withstand the thermal effects of hypersonic flight.

At present, a program of production and testing of fasteners made from the relatively new 7 Al, 4 Mo titanium alloy is underway. It is believed that these fasteners may provide the practical answer to service at elevated temperatures in the 1000 F plus range.

Impact and fatigue properties of

Ductile Cast Iron

By CHARLES F. WALTON
Technical Director
Gray Iron Founders' Society Inc.
Cleveland, Ohio

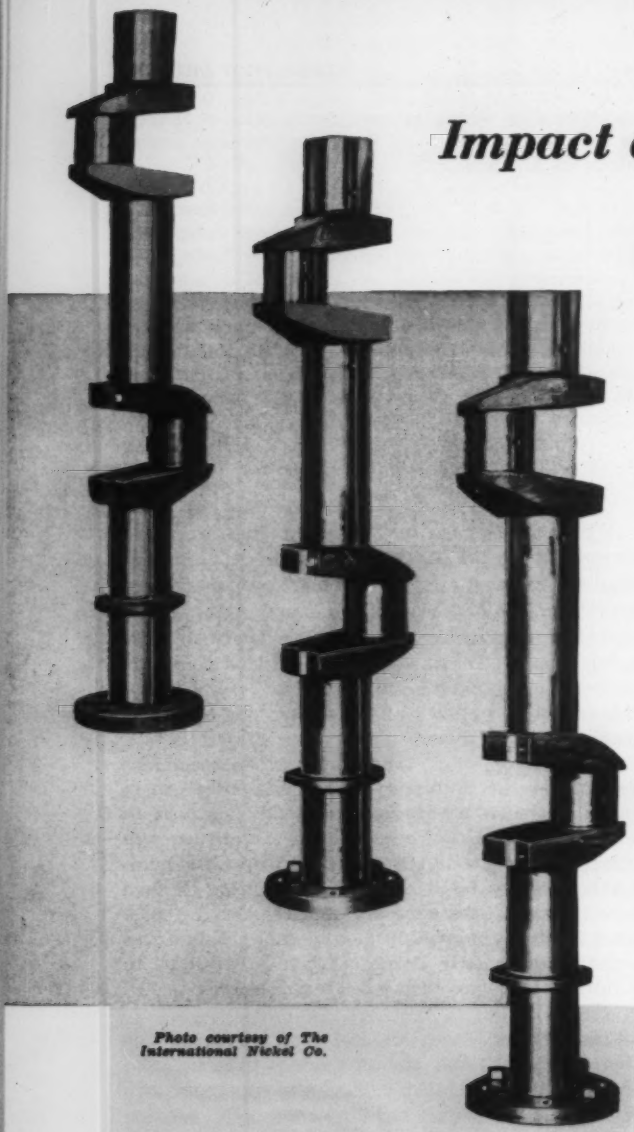

Photo courtesy of The International Nickel Co.

FOR ductile or nodular cast irons, impact strength and fatigue resistance are two properties which are extremely significant in design.

Ductile cast iron can stand considerable shock in service, but methods of measuring impact properties must be understood to make an intelligent comparison between different ductile irons. Composition of the iron, heat treatment, and high service temperatures all affect impact properties.

As with other metals, fatigue properties of ductile iron are influenced by notches or stress raisers, and surface finish. Heat treatment seems to have less effect in improving fatigue properties.

These main factors and their significance in evaluating both impact and fatigue characteristics of ductile iron are discussed in this article.*

▶ Impact Properties

Ability of ferritic irons to deform and absorb energy during fracture is influenced by temperature changes. Impact tests are conducted over a range of test temperatures, so that the fracture varies from a ductile type with high energy absorption and a fibrous fracture appearance, to a brittle type with low fracture energy and a crystalline fracture appearance. Transition temperatures vary for different ferritic materials and are influenced by microstructure and composition. Irons with an austenitic matrix, such as high-nickel Ni-Resist ductile irons, do not exhibit this abrupt transition. Metals exhibiting low transition temperatures are less susceptible to brittle failure in severely stressed applications than similar materials that exhibit high transition temperatures.

Influence of a notch on impact energy absorbed during fracture and on transition temperature from ductile to brittle fracture is shown for a ferritic ductile iron in Fig. 1. The British Cast Iron Research Association's ½ by ¾-in. Charpy V-notched test piece is shown in Fig. 2. Even though the frac-

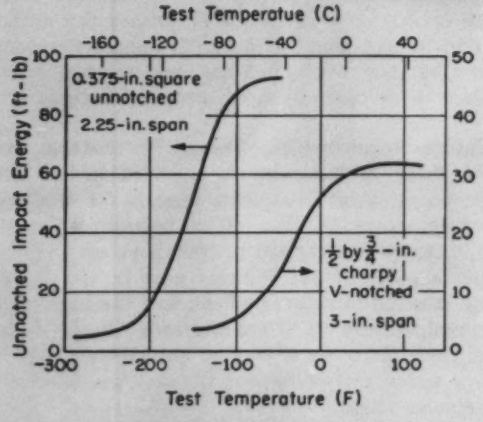

Fig. 1—Transition temperature ranges for ferritic nodular iron with notched and unnotched specimens. The notch raises the transition temperature and decreases energy value.

*Based on "Properties of Gray Iron," from the *Gray Iron Castings Handbook*.

- **temperature effects**
- **structure and composition**
- **heat treating effects**
- **notch sensitivity**
- **surface finish**

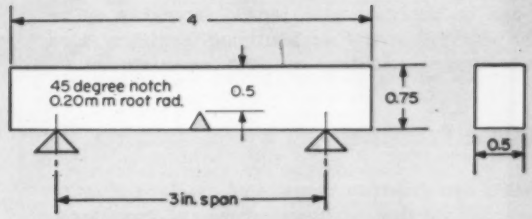

Fig. 2—Dimensions of the British Cast Iron Research Association's Charpy-type impact test piece

tured area of the notched specimens was considerably larger than in the unnotched specimens, the embrittling influence of a notch is indicated by the lower absorbed energy during ductile fracture and the higher transition temperature with the notched specimen. The unnotched impact test largely measures energy required to initiate a crack, and the notched-bar impact test largely measures energy required to propagate a crack. Work done in initiating a crack is relatively low because of the stress concentrating effect of the notch. It has also been stated as a result of explosion tests that ductile cast irons, in the absence of sharp cracks, are capable of enduring considerable abuse before failure. This indicates that ductile iron is capable of withstanding considerable shock in service, and that transition temperature is an important criterion in evaluating behavior under shock loads.

Influence of Structure and Composition: Impact resistance of ductile irons as indicated by transition temperature and absorbed energy is considerably influenced by both structure and composition. Fully ferritic ductile irons have the best toughness, and this toughness decreases with increasing amounts of pearlite in the matrix microstructure,[1] Fig. 3. Increasing quantities of both phosphorus and silicon also reduce impact resistance of nodular iron. The superiority of a 0.08 per cent phosphorus nodular iron compared with an iron containing 0.16 per cent phosphorus is shown in Fig. 4, and the effect of increasing silicon content from 1.0 to 2.0 to 2.7 per cent in reducing toughness[2] is shown in Fig. 5. Normal variations in manganese, nickel, or copper content, however, have not shown any significant effect on toughness.

Effects of Heat Treating: Strength of iron can be increased and good toughness maintained by special heat treating techniques. Conventional austenitizing treatment, followed by quenching and tempering, sharply reduces impact resistance because of the high combined carbon content retained by quenching. However, employment of a low, partially austenitizing temperature for quenching yields good toughness as measured by a specially

[1]References are tabulated at end of article.

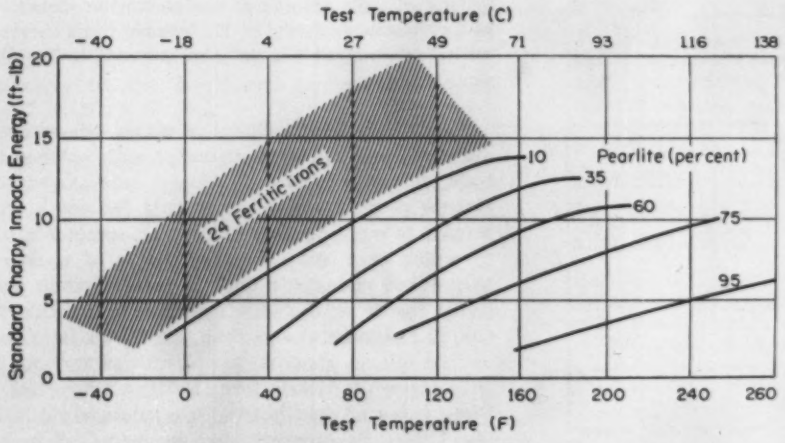

Fig. 3—Effect of matrix microstructure on impact strength of ductile iron in standard 10 mm, V-notched Charpy test bar. Toughness decreases with increase of pearlite in the matrix microstructure.

notched specimen in a drop weight test. This toughness can be obtained with tensile strengths up to 90,000 psi. The partial austenitizing treatment also permits water quenching without cracking.

Fatigue Properties

Metals can fracture because of cyclic loading or repeatedly varying stresses which, at maximum, are considerably below yield strength. The resulting fatigue fracture resembles that of a brittle material even when it occurs in very ductile metals. Stress concentrators, such as notches, are detrimental to fatigue life, but speed of the loading cycle and occurrence of "rest" periods are not critical.

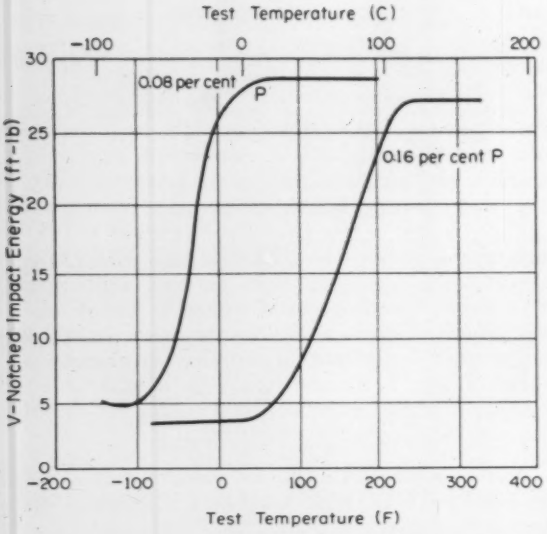

Fig. 4—Above—Effect of a varying phosphorus content on impact properties of two annealed, ferritic, ductile-iron V-notched Charpy test bars

Fig. 5—Below—Effect of silicon content on impact properties of annealed, ferritic, ductile-iron V-notched Charpy test bars

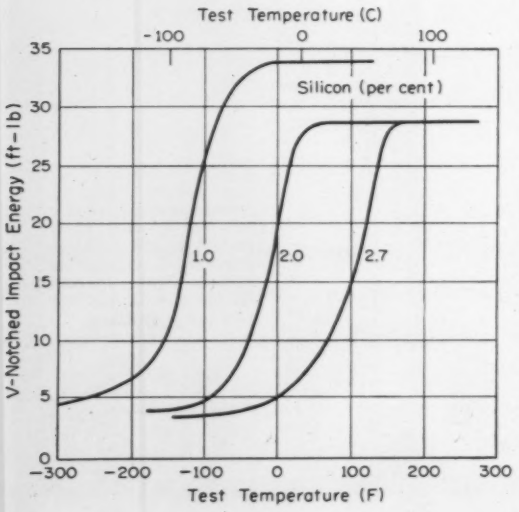

Table 1—Summary of Fatigue Properties of Ductile Iron

Type	Tensile Strength (psi)	Unnotched: Endurance Limit (psi)	Unnotched: Endurance Ratio	V-Notched: Endurance Limit (psi)	V-Notched: Endurance Ratio	Notch Sensitivity Factor
60-45-10	71,000	30,500	0.43	21,000	0.30	1.4
80-60-03	90,000	40,000	0.44	24,000	0.27	1.7
120-90-02*	135,000	49,000	0.36	30,000	0.22	1.6

*Oil quenched from 1650 F and tempered at 1100 F.

Table 2—Fatigue Data for Hardened and Tempered Ductile Iron

Property	As-Cast	Quenched and Tempered*	Quenched and Tempered†	As-Cast	Normalized‡
Hardness (bhn)	255	295	350	267	325
Tensile strength (psi)	96,300	134,500	149,300	95,600	151,000
Elongation (per cent)	3	4	1.5	2	4
Endurance limit (psi)					
Unnotched	40,300	49,300	49,300	43,700	49,300
Notched	25,800	30,200	28,200	30,200	30,200
Endurance ratio	0.42	0.37	0.46	0.46	0.33
Notch sensitivity	1.56	1.63	1.44	1.44	1.63

*Oil quenched from 1650 F (900 C) tempered 2 hr at 1110 F (600 C).
†Oil quenched from 1650 F (900 C) tempered 2 hr at 1020 F (550 C).
‡Normalized from 1650 F in ⅜ by 8½-in. pieces.

As maximum stress is reduced, number of cycles necessary to produce a failure becomes much larger. The highest stress at which the number of cycles for failure approaches infinity (generally in excess of 10 million) is the endurance limit. Endurance ratio is the relation between endurance limit and tensile strength of a material.

Most data on fatigue strength have been obtained with rotating-beam type tests where maximum stress alternates between tension and compression. A typical *S-N* curve on which stress is plotted against number of cycles to failure shows that the unnotched endurance limit is 28,000 psi. This is the maximum stress at which a fatigue failure should not occur under similar conditions in any number of cycles. Endurance limit increases with tensile strength, but the increase is less than proportional.

Notch Sensitivity: Effect of stress raisers on endurance limit has been evaluated with notched test bars. A notch is usually turned into the circumference of an oversize bar so that the notch cross-section is equal to that of regular, unnotched bars to which they are compared. Ratio of unnotched to notched endurance limit is termed notch sensitivity factor or dynamic stress concentration factor. It has been shown that this factor is affected by the silicon content in pearlitic as well as ferritic types of ductile iron. Fatigue properties for three types of ductile iron[3] are summarized in Table 1. Tensile strength can be increased in heat treating by normalizing or by oil quenching and

tempering,[4, 5] Table 2, but fatigue strength is not increased to the same degree.

Effects of Surface Finish: Shot-peening or rolling of the surface is known to increase endurance limit of a part. Surface rolling is very effective in increasing the fatigue strength of V-notched ductile-iron fatigue test specimens.[6] Endurance limit of the pearlitic (higher strength) type was increased as much as 140 per cent and the ferritic (high ductility) type 190 per cent when the V-notch in the circumference of the test bars was rolled with a formed roller under pressure. More than 60 per cent increase in endurance limit was obtained with a rolling pressure that was insufficient to depress the surface a measurable amount. The higher values of endurance were obtained when the notched diameter (0.417 in.) was reduced 0.021 in. by rolling.

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This article is the third in a co-ordinated group of three based on "Properties of Gray Iron," from the *Gray Iron Casting Handbook*. The previous articles and issues of MACHINE DESIGN in which they appeared are:

Fatigue Properties of Gray Iron .....December 12, 1957
Impact Resistance of Gray Iron .....December 26, 1957

Tips and Techniques

Modeling Aid

Nails are helpful when doing scale modeling of machine parts in clay or similar media. The desired dimensions are calipered and nails are inserted into the clay model. The calipers are used to gage the depth and spacing of the nails inserted. Clay is added so that the nail head is just hidden. By inserting the nails wherever it is desired to gage a dimension, accurate models can be constructed. The nails also serve as strengtheners. —DAVID ARNOLD, *product designer, Milwaukee, Wis.*

Logarithmic Interpolation

Interpolation between two curves of a logarithmically spaced family can be facilitated by use of a slide rule. The decimal-fractional distance of the required point between the two curves is first measured. The slide-rule hair line is then set to this value on the L (linear) scale and the interpolation fraction read on the D scale. For example, for a point midway between two curves, the decimal fractional distance is 0.5. Opposite 5 on the L scale, 0.318 is read on the D scale as the interpolation fraction.—JESSE ROTH, *New York, N. Y.*

Solving Triangles

One side of a triangle can be found with this rapid method using a log-log-duplex-trig sliderule:

To find a hypotenuse, given two sides:

1. Set index on the S scale, opposite the value on D scale for the larger leg of the triangle.
2. Set hairline over value of the smaller leg on D scale.
3. Read the angle on the T scale. Since the ratio of sides is greater than unity, the angle will be greater than 45 deg.
4. Now, slide the same angle, on the S scale, under the hairline and read the hypotenuse under the index on the S scale.

EXAMPLE: Find the hypotenuse given two sides, 7.9 and 13.6:

1. Set S-scale index over 13.6 on D scale. Set hairline over 7.9 on D scale and read 59°51′ on T scale.
2. Set 59°51′ on S scale under hairline and read 15.73 at index on the D scale.

To find one side, given hypotenuse and other side:

1. Set S-scale index on the hypotenuse on D scale.
2. Set hairline on the known side on the D scale and read the angle on the black S scale.
3. Set the hairline on the red S scale and read unknown side on the D scale.

EXAMPLE: Find one side, given the other side, 11.6, and hypotenuse, 15.7:

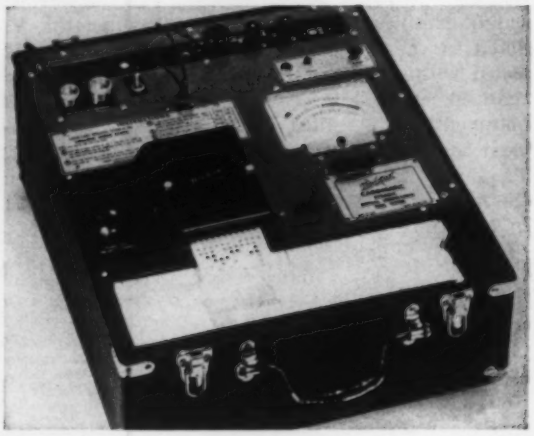
1. Set S-scale index on 15.7 and hairline on 11.6 on D scale; read 47°40′ on the black S scale.
2. Set hairline to 47°40′ on red S scale and read 10.57 on D scale.

—LOUIS TONIK, *physicist, Pitman Dunn Laboratories, Frankfort Arsenal, Philadelphia, Pa.*

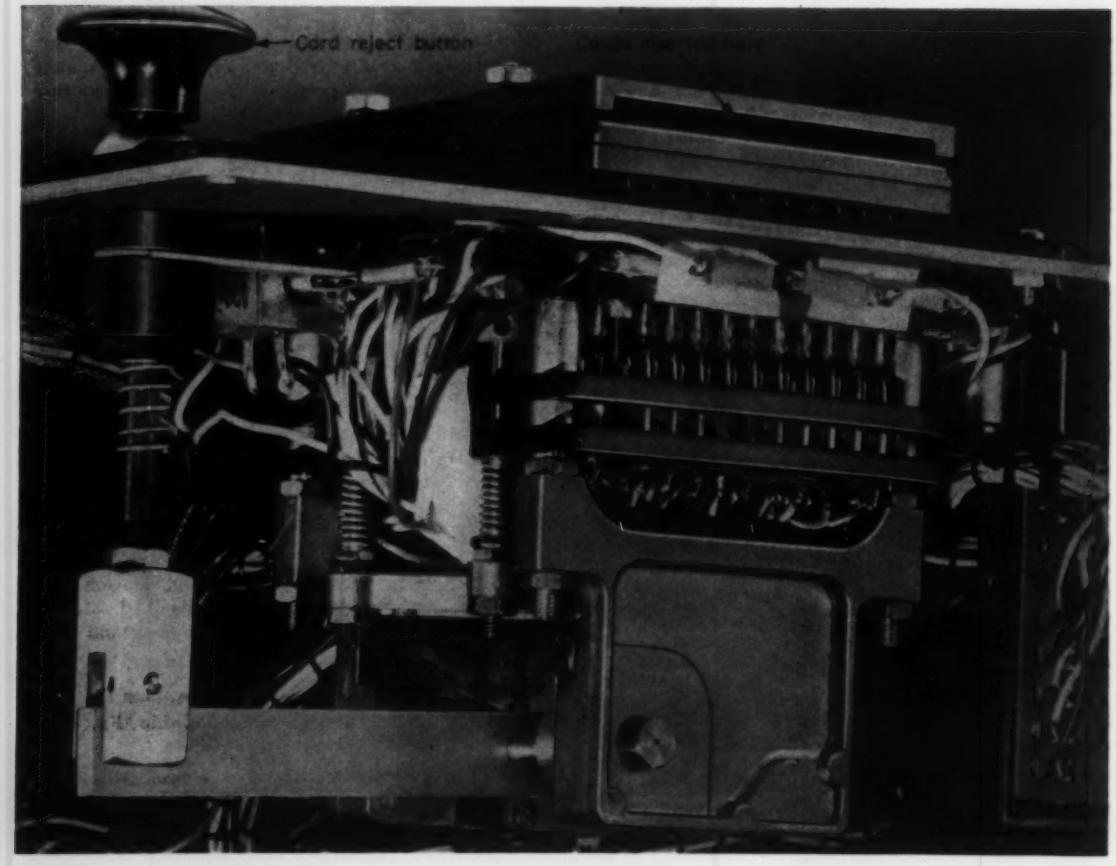
Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Automatic Selection of Voltages

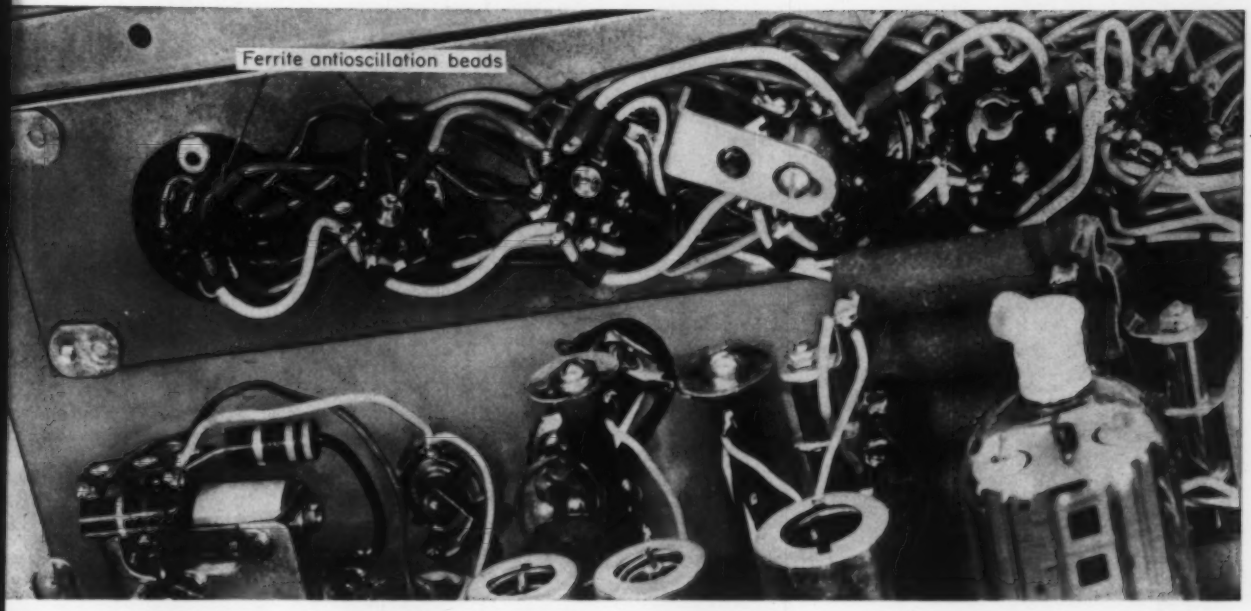
AUTOMATIC TESTING of tubes is accomplished with laboratory accuracy in a new tube-testing machine. Designed by the Hickok Electrical Instrument Co., the Model 123A Cardmatic utilizes punched plastic cards to set and test electronic tubes automatically for specific circuit requirements.



PRESELECTED VOLTAGES on screen, plate, grid, or filament are tabulated on vinyl plastic cards which are inserted into the machine. These cards trip an automatic mechanism which makes all electrical connections necessary for testing any receiver tube. The switching mechanism is built with 187 individual switches that provide a large number of accurately controlled voltage combinations. The 187 switches can provide a total 12.6×10^{56} switch combinations.

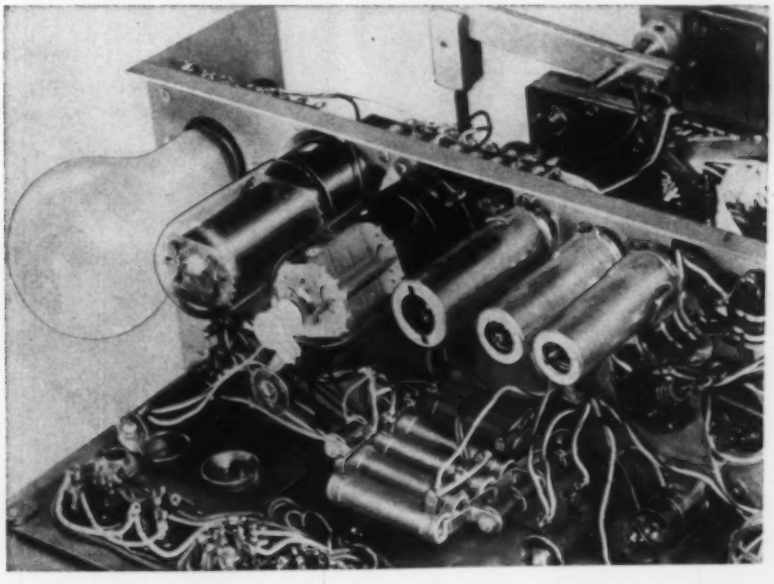


with Punched Plastic Cards

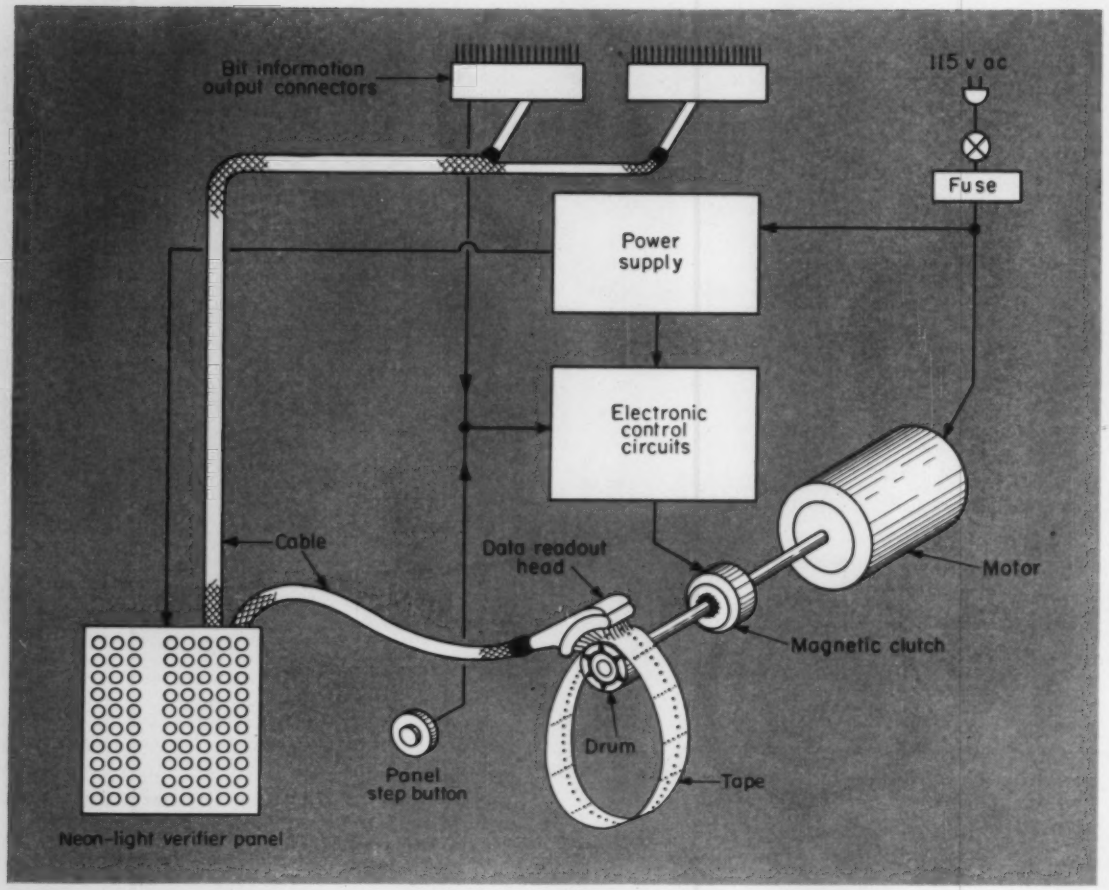


ANTIOSCILLATION BEADS slipped over wiring close to the tube sockets prevent any erroneous meter indications which might be caused by parasitic oscillations. The beads are made of ferrite magnetic material and provide a specific amount of built-in circuit inductance which prevents unwanted circuit oscillations at the higher frequencies.

OVERLOAD PROTECTION for the filament transformer used in the testing instrument is provided with a novel application of an electric lamp in the circuit. A 100-watt light bulb is wired in series with the transformer and automatically asborbs overload power surges which might burn out the transformer. A light bulb is used as a circuit-protection element instead of a fuse or circuit breaker. The resistance of the lamp filament is comparatively low when unlit, but increases appreciably when lighted providing a ballasting action.

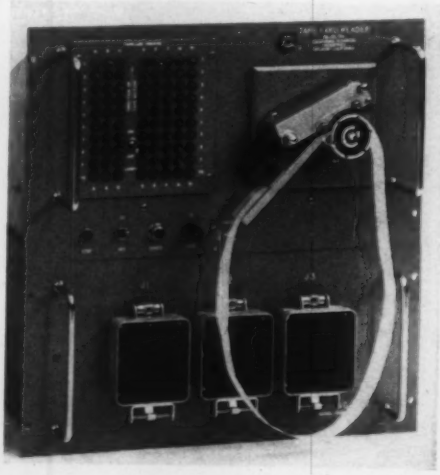


Readout Head with Wire Brush Fingers



DRIVE SYSTEM for the tape-transport drum in the CTI Supertester consists of a continuously running motor, a magnetic clutch, and an electronic control unit. Drum rotation and stopping is controlled to move the tape just one frame (ten lines of holes) with each step. The clutch is energized by a 10-millisecond pulse of current for each step. About 0.5 millisecond is required to build up current, engage the clutch, and start rotation, and 1 millisecond for disengaging clutches.

Drum rotation is stopped by a cam-actuated lever which is lifted into the path of a dog on a latching wheel. Rebound is controlled by a spring-actuated lever which drops in behind the dog. Final positioning of the drum is controlled by an adjustable detent.



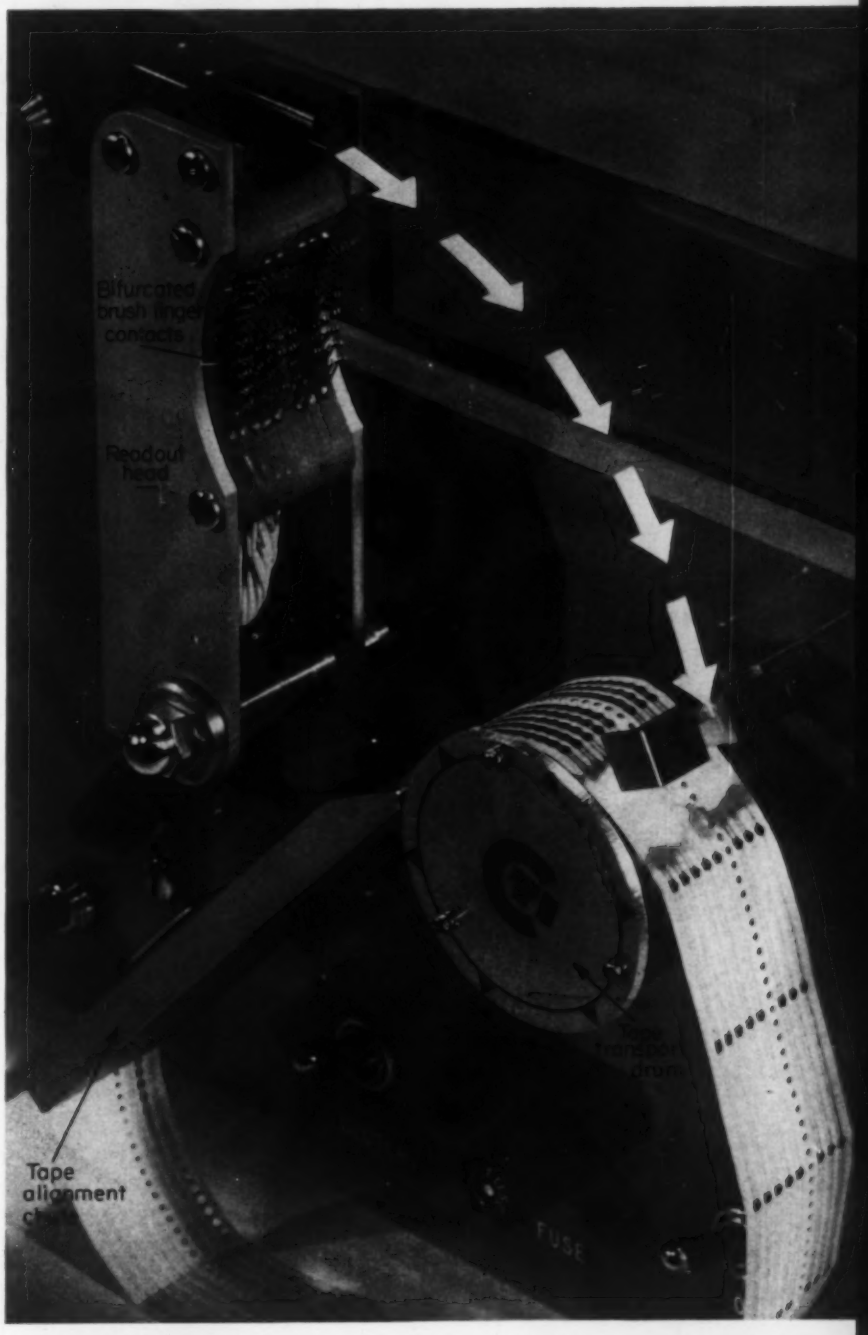
AUTOMATIC TESTING of individual components and voltages in electronic assemblies is accomplished by a novel tester built by California Technical Industries. The unit is designed to read 80 bits of data simultaneously from a 1-in. perforated paper tape.

Detects 80 Signals Simultaneously

DATA READOUT HEAD contains 80 sets of bifurcated brush fingers which drop through perforated tape holes, making contact with the tape transport drum. The hook-shaped ends of wire brush fingers are soldered to 80 brass pins which are molded in a plastic member in the brush head. Molding and soldering are done so that all brush fingers ride the drum at the proper angle and pressure. The brush fingers are made of an alloy of platinum palladium, gold, copper, and silver. Each finger has a current capacity of 50 ma. The drum is silver plated for low resistance.

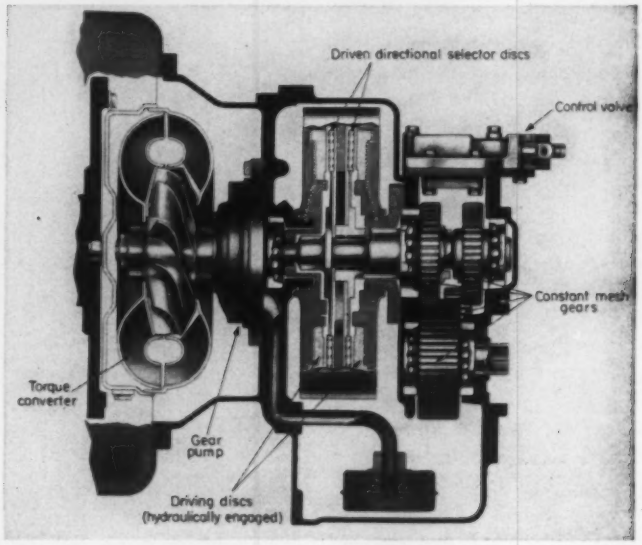
The brush head is mounted in a pivot arm which may be lifted away from the drum to facilitate loading and unloading of the tape. When the arm is swung back into place, metal guides assure that the brush head returns to exactly the same position each time. The flow of tape approaching the drum is controlled by a tape alignment chute, to preclude any possibility of misalignment of drive holes with sprocket pins. Markings are provided on the drum to indicate frame location so that the tape may be easily loaded in the proper position.

A matrix of 80 lamps is provided on the front panel to indicate which brush fingers are making contact with the drum.



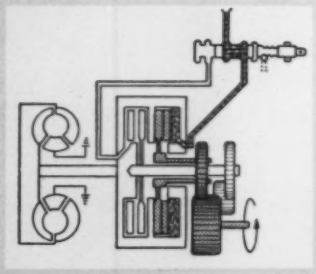
Direction of Torque-Converter Drive Output Controlled with Hydraulically Locked Discs

HYDRAULIC POWER SHIFTING feature in a new torque converter drive eliminates manual clutching and gear shifting. The drive design is used in Allis-Chalmers lift trucks.

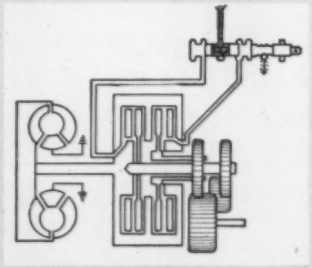


TORQUE-CONVERTER OUTPUT can be connected to the output through two directional selector discs or clutches. One disc-type clutch, when engaged, turns the drive output shaft in one direction, and the other disc in the other direction.

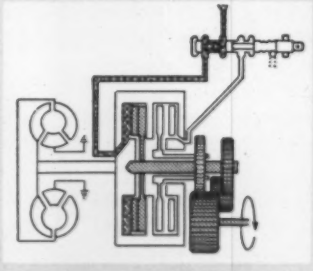
The self-contained hydraulic control valve is mounted directly on the drive and has no external piping. Internal preset relief valves automatically adjust hydraulic pressures.



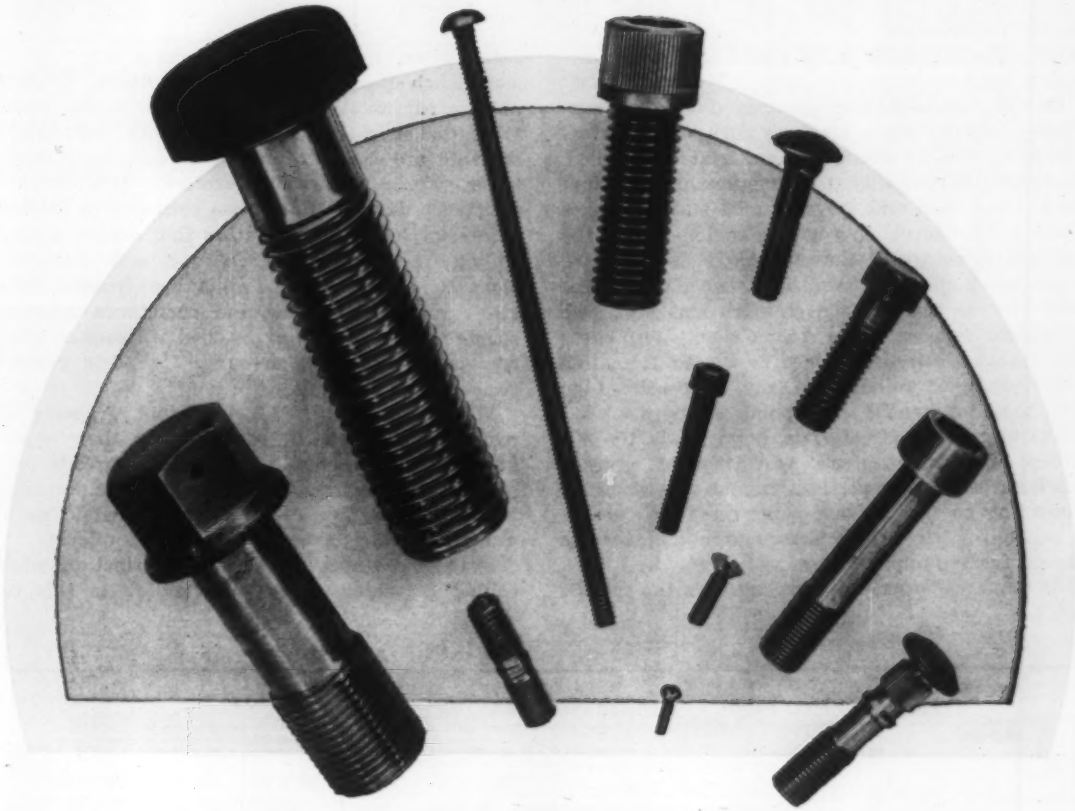
IN FORWARD POSITION, selector valve permits oil pressure to build up against the right driving disc, pushing it into friction contact with the right directional selector disc, which in turn transmits power to hollow driveshaft, engaging forward gears.



IN NEUTRAL POSITION, hydraulic selector valve shuts off flow of oil to both driving discs.



IN REVERSE POSITION, selector valve meters oil under pressure against the left driving disc bringing it into friction contact with the left directional selector disc, which in turn transmits power to a solid shaft, engaging reverse gears.



Material selection for

Thread and Form Rolling

ROLLABILITY—the behavior of materials during thread rolling—is related to material properties such as hardness, strength, ductility and toughness. However, no predictable relationship has been established between any one or any combination of these properties and rollability.

Three rather distinct considerations are used to determine rollability.

1. Resistance of material to plastic deformation.
2. Behavior of material during displacement.
3. Degree of smoothness of material rolled.

Resistance to Plastic Deformation: Resistance of the material to plastic deformation is probably the most important element of rollability because it determines load placed on the dies, number of pieces the dies will produce before die failure occurs, and power required to roll the material. Total resistance to plastic deformation is a combination of several properties. Among these are yield point, hardness, internal frictional resistance developed during plastic deformation, and work hardenability.

YIELD-POINT STRENGTH: This may be defined as the stress, in psi, beyond which a material will undergo permanent or plastic deformation. Yield point commonly reported is that obtained from standardized tensile tests. In cases of compression of cylindrical bars of lengths equal to two or three times the diameter, the compressive yield point is very nearly the same as that obtained from standard tensile tests. However, in localized compression between surfaces where the contact area is relatively small compared to total surface area, resistance to permanent or plastic deformation may reach several times the tensile yield point. This resistance to compression may even reach values several times the ultimate tensile strength.

Comparison of tensile yield points of carbon steel (AISI C1015) and 302 stainless steel shows tensile yield points averaging approximately 45,000 psi. Yet, there is a vast difference in behavior of these materials: It takes over twice as much power to roll 302 as it does low-carbon steel. Heat-treated alloy steel of Rockwell C 40 hardness has a yield point of approximately 150,000 psi and

takes three times as much power to roll as low-carbon steel.

In the thread-rolling process, dies are progressively forced into a blank as they roll. Penetration is resisted by strength of material being rolled. Resistance is primarily from compression, although final dislocation and movement of material takes place in the form of a sliding action within the internal structure of the material.

For some materials there is rather good correlation between tensile yield strength and resistance to plastic deformation in compression. With these materials, relative resistance to thread formation (one phase of rollability) may be predicted on the basis of tensile yield-point strength.

Other groups of materials, particularly the 300 group of stainless steels, which exhibit marked work-hardening properties, cannot be classified according to tensile yield-point strength. Resistance to further plastic deformation increases as thread formation progresses.

INTERNAL FRICTION: Developed during plastic deformation, internal friction makes some materials much harder to move than others. It does not appear to be correlated with tensile yield strength, since some materials with high yield strength are easier to move than some with much lower. Force required to overcome this internal resistance during deformation seems to be related to amount of axial elongation that occurs during rolling. Low carbon steels and soft materials elongate during rolling, while heat-treated alloy steels are much stiffer and sometimes actually spring back after rolling. Added stiffness of some free-machining steels accounts for their greater resistance to rolling.

WORK HARDENING: An important property of materials that effects rollability is their work-hardening characteristics. Rolled threads are stronger than cut threads because of this property. Most materials work-harden, but some do so to a much greater extent than others, offering increasing resistance to plastic deformation while rolling is taking place. Outstanding in this re-

Table 1—Rollability: Carbon and Alloy Steels

Material		AISI Number	Finish on Threads[2]	Rollability[1] Relative Die Life			
				Soft	15-25 Rc	26-32 Rc	33-40 Rc
Carbon steels:	Straight carbon	C1005-C1095	E	H	H-M	M	L
	Free cutting	C1111-C1144	G	H	H-M	M	..
		B1111-B1113[3]	F	H	..	..	..
Leaded steels:	Free cutting	C1018-L[4]	E	H	..	..	..
		C1045-L	E	H	M	..	..
		C1117-L	G	H	..	..	..
		C1141-L	G	H	M	..	..
		C1213-L	G	H	M	..	..
		4140-L	E	H	M	..	..
		4150-L	E	H	M	..	..
		8620-L	E	H	..	..	..
		8647-L	E	H	M	..	..
Alloy steels[5]:	Manganese	1320-1340	E	H	H-M	M	L
	Nickel	2317-2345	E	H	H-M	M	L
		2512-2517					
	Nickel-chrome	3115-3150	E	H-M	M	M-L	L
		3310-3316					
	Molybdenum	4017-4068	E	H-M	M	M-L	L
	Chromium-molybdenum	4130-4150	E	H-M	M	M-L	L
	Nickel-chromium-molybdenum	4317-4340	E	H-M	M	M-L	L
		8615-8660					
		8719-8750					
		9310-9317					
		9437-9445					
		9747-9763					
		9840-9850					
	Nickel-molybdenum chromium	4608-4640	E	H-M	M	M-L	L
		4812-4820					
		5045-5046	E	H-M	M	M-L	L
		5120-5160					
		50100-52100					
	Chromium-vanadium	6120-6152	E	H-M	M	M-L	L
	Silicon-manganese	9255-9262	G	H-M	M	M-L	L
Tool and die steel:	High carbon, high chromium	.....	E	..	M	L	..
Stainless steel:	301-347[6]	.....	E	..	M	L	..
	403-446[7]	.....	E	..	M	L	..
High-speed steels:	Tungsten (18-4-1)	.....	E	..	M	L	..
	Molybdenum (M-2)	.....	E	..	M	L	..
Nitriding steels:	Nitralloy 135, 230, N, EZ[8]	.....	E	..	M	M-L	..

1. H=High; M=Moderate; L=Low.
2. E=Excellent; G=Good; F=Fair; P=Poor.
3. Not suitable for wide root or crest flats, such as Acme threads.
4. Lead added to standard steels to improve machinability.
5. Lower carbon ranges are in carburizing class and are rolled soft. Steels with carbon in excess of 0.25 are in oil-hardening class and are rolled after heat treat.
6. No seam is produced in thread crest.
7. Slight to moderate seam in crest should be expected.
8. Must be rolled before nitriding.

Table 2—Machinability: Carbon and Alloy Steels

Material		AISI Number	Hardness Brinell	Hardness Rockwell* B Scale	Hardness Rockwell* C Scale	Machinability (B1112=100)
Carbon steels:	Straight carbon	C1008	126-163	72- 85	-(3)	50
		C1010	131-170	74- 87	-(5)	50
		C1015	131-170	74- 87	-(5)	50
		C1020	137-174	76- 88	-(6)	65
		C1022	159-192	84- 92	(2)-(12)	70
		C1030	170-212	87- 96	(5)-(16)	65
		C1035	174-217	88- 97	(6)-(19)	65
		C1040	179-229	89- 98	(8)- 21	60
		C1045	179-229	89- 98	(8)- 21	60
		C1050	179-229	89- 98	(8)- 21	50
		C1070	183-241	90-100	(9)- 23	45
	Free cutting	C1109	136-166	76- 86	-(4)	85
		C1115	143-179	79- 89	-(8)	85
		C1117	143-179	79- 89	-(8)	85
		C1118	143-179	79- 89	-(8)	80
		C1120	143-179	79- 89	-(8)	80
		C1132	187-229	91- 98	(10)- 21	75
		C1137	187-229	91- 98	(10)- 21	70
		C1141	183-241	90-100	(9)- 23	65
		B1111	179-229	89- 98	(8)- 21	95
		B1112	179-229	89- 98	(8)- 21	100
		B1113	179-229	89- 98	(8)- 21	135
Leaded steels:	Free cutting	C1018-L	135-172	75- 88	-(6)	80
		C1045-L	179-229	89- 98	(8)- 21	75
		C1117-L	143-179	79- 89	-(8)	130
		C1141-L	183-241	90-100	(9)- 23	90
		C1213-L	179-229	89- 98	(8)- 21	180
		4140-L	187-229	91- 98	(10)- 21	90
		4150-L	187-235	91- 98	(10)- 21	85
		8620-L	170-215	87- 96	(5)-(16)	90
		8647-L	183-235	90- 99	(9)- 22	77
Alloy steels:	Manganese steels	1320	170-229	87- 98	(5)- 21	50
		1330	179-235	89- 99	(8)- 22	50
		1335	187-241	91-100	(10)- 23	50
		1340	187-241	91-100	(10)- 23	45
	Nickel steels	2317	174-217	88- 96	(6)-(16)	55
		2330	179-229	89- 98	(8)- 21	50
		2340	187-241	91-100	(10)- 23	45
		2515	179-229	89- 98	(8)- 21	30
	Nickel-chromium	3120	163-207	85- 95	(3)-(15)	60
		3130	179-217	89- 96	(8)-(16)	55
		3140	187-229	91- 98	(10)- 21	55
		3145	187-235	91- 99	(10)- 22	50
		3310	170-229	87- 98	(5)- 21	40
	Molybdenum steels	4023	157-207	83- 95	(1)-(15)	70
		4027	166-212	86- 96	(4)-(16)	70
		4032	170-229	87- 98	(5)- 21	65
		4037	179-229	89- 98	(8)- 21	65
		4042	183-235	90- 99	(9)- 22	60
		4047	183-235	90- 99	(9)- 22	55
	Chromium-molybdenum	4130	187-229	91- 98	(10)- 21	65
		4137	187-229	91- 98	(10)- 21	60
		4145	187-229	91- 98	(10)- 21	55
		4150	187-235	91- 98	(10)- 21	50
	Nickel-chromium-molybdenum	4320	179-228	89- 98	(8)- 21	55
		4340	187-241	91-100	(10)- 23	45
		8620	170-215	87- 96	(5)-(16)	60
		8630	179-229	89- 98	(8)- 21	65
		8640	179-229	89- 98	(8)- 21	60
		8645	183-235	90- 99	(9)- 22	55
		8650	183-241	90-100	(9)- 23	50
		8720	170-217	87- 96	(5)-(16)	60
		8730	179-229	89- 98	(8)- 21	65
		8740	179-229	89- 98	(8)- 21	60
		8745	183-235	90- 99	(9)- 22	55
		8750	183-241	90-100	(9)- 23	50
		9315	179-229	89- 98	(8)- 21	40
		9440	179-229	89- 98	(8)- 21	60
	Nickel-molybdenum	4615	174-217	88- 96	(6)-(16)	65
		4640	187-235	91- 99	(10)- 22	55
		4815	187-229	91- 98	(10)- 21	50
	Chromium steels	5120	170-212	87- 96	(5)-(16)	65
		5140	174-229	88- 98	(6)- 21	60
		5150	179-235	89- 99	(8)- 22	55
	Chromium-Vanadium	6120	179-217	89- 96	(8)-(16)	50
		6145	179-235	89- 99	(8)- 22	50
		6152	183-241	90-100	(9)- 23	45
	Silicon-manganese	9260	187-255	91-102	(10)- 25	45
		9261	179-217	89- 96	(8)-(16)	50
Tool and die steel:	High-carbon, high-chrome	....	192-241	92-100	(12)- 23	25
Stainless steels:		302	150	82	...	25
		303	160	84	(2)	55
		316	150	82	...	25
		321	160	84	(2)	25
		347	160	84	(2)	25
		410	155	83	(1)	50
		416	155	83	(1)	60
		420	179	89	(8)	45
		430	155	83	(1)	45
		440	223	97	(19)	35
		443	187	91	(10)	50
High-speed steels:	Tungsten (18-4-1)	...	192-241	92-100	(12)- 23	30
Nitriding steels:	Molybdenum (M-2)	...	192-241	92-100	(12)- 23	35
		...	223-263	97-103	(19)- 27	45

*Rockwell C values in parentheses are beyond normal range and are used only as a guide.

spect is 302 stainless, while 416 stainless (12 per cent Cr) is not.

HARDNESS: Results of recent and continuing research indicate that Rockwell or Brinell hardness numbers give a very good indication of relative resistance to thread formation as long as the same general group of materials is being dealt with. At present it does not appear promising that a single physical property may be used as the final criterion of rollability. There is a vast difference in manner in which different groups of material behave during formation of threads.

Behavior During Displacement: Some materials roll with a seam in the crest of the thread. This seam is present to varying degrees and is not always visible to the eye, but can be revealed by etching and magnification. Those familiar with the process are aware of this seam and appreciate that it has little, if any, effect on thread strength. Threads do not fail through the crest, either in static loading or fatigue. Loaded threads are most highly stressed in the root, and this is the area most benefitted by thread rolling. Rolled threads are stronger than any type of cut threads in static loading—and especially so in fatigue.

Materials displace differently during rolling. How some materials are affected when the dies first penetrate the blank is shown in Fig. 1. Area affected is large and relatively deep. Areas worked by each die crest overlap, causing the section midway between roots of the thread to ultimately move upward faster than material at flanks of the threads. Several stages in rolling of the thread are shown to demonstrate why material behaving in this manner rolls without a seam.

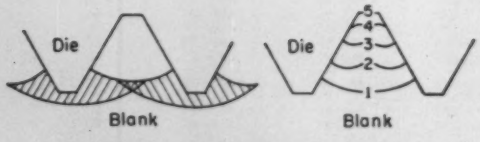


Fig. 1—Material flow during penetration of die, showing reaction of material when area affected by die pressure is wide and deep. Perfect threads form in materials of this type, without crest seams.

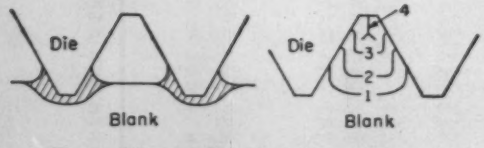


Fig. 2—Material flow during penetration of die, showing evolution of crest seam. The seam occurs when affected area is small and confined largely to surface layers.

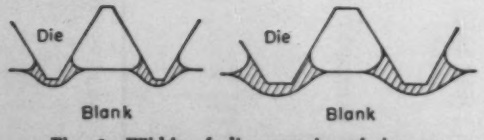


Fig. 3—Width of die crest in relation to thread pitch influences contact area and movement of material between die crests.

CREST SEAMS: Fig. 2 shows how other materials are affected when dies first penetrate the blanks. Areas affected are small and confined to surface layers. Section of the blank midway between crests of the die is not affected at all. During die penetration, a seam is formed in the final full thread. It is possible to roll full enough so that metal in the crest is so tightly squeezed that no seam is visible to the eye. No amount of squeezing, however, will eliminate the seam once it has formed.

Several factors influence behavior of materials with respect to the seam in the crest. Some of these are physical properties of the materials; some are factors of the thread-rolling process. If material has a high degree of stiffness or internal friction, it will be more difficult to move surface layers over deeper layers. Deeper layers will be moved too, and the area affected by die penetration will be deeper and more extensive.

As small surface areas are plastically deformed, they work-harden and have a higher yield point. By the time the next die contact is made, strength of surface layer may be high enough so that unworked layer under it reaches its yield point before the surface layer does. Thus areas affected extend rapidly with each die contact.

Width of crest flat of the die in relation to pitch will obviously influence area of material affected by each contact, Fig. 3. Rate of die penetration per contact affects extent of the seam. Rates of penetration are considerably higher in flat-die rolling than they usually are in cylindrical-die rolling, and extent of seam produced is somewhat less in flat-die rolling. While high penetration rates may be effective in reducing extent of the seam, as yet there appears to be no completely effective method of rolling some materials without producing a seam, even though the seam can be hidden from the eye by rolling the thread full.

As-Rolled Smoothness: Ductility of materials has an important effect on use of thread rolling and appears to be closely related to degree of surface smoothness obtained; the most ductile materials roll with the smoothest surfaces. Most materials, however, roll with smooth surfaces. Some products, such as metal stampings, require use of ductile materials. It is very difficult to cut smooth threads in materials used in cold stamping and forming because of their extreme ductility. Such materials roll easily and lend themselves readily to rolled threads. A very smooth thread surface is achieved by rolling 302 stainless, high-speed, and high-carbon steels.

Free-machining steels and nonferrous metals are widely used for rolling threads. Sulfur and man-

ganese are added to steels, and lead to nonferrous materials, to make the chips more brittle and thereby cause them to break as they are removed. These elements in materials are also apt to cause flaking when rolling 29-deg Acme and worm threads, and give roughened roots to these and similar threads with wide root flats.

Commonly Rolled Materials

Straight carbon steels, structural-alloy steels, high-speed steels, nonleaded brasses, and copper constitute the majority of materials used in producing parts calling for rolled threads and forms. Among this wide variety of materials, many variations in rolling characteristics and finishes are experienced.

Selection of materials often depends upon an optimum combination of rollability and machinability. To aid in making selections for more commonly used carbon and alloy steels, Tables 1 and 2 show material rollability and machinability ratings. Machinability ratings for steels are given for the hardness most commonly machined. Tables 3 and 4 give similar information for nonferrous and aluminum alloys.

Carbon Steels: Straight carbon steels, with standard allowable quantities of phosphorus and sulfur, are ideal materials to roll. Excellent finishes are obtained with minimum rolling pressures. Free-cutting steels having sulfur amounts of 0.08 to 0.33 per cent require about the same amount of power for rolling as straight carbon steels, but finish is not quite the same. Finish is good on standard 60-deg threads but not as good on threads with wide root or crest flats and steep sidewalls, such as 29-deg Acme threads. Finish is improved by modification of thread form to give narrower die crests and liberal radii and by selecting grades of steel which have smaller percentages of sulfur and phosphorus. For example, C1115 is preferred to B1113.

Leaded Steels: Lead is often added to carbon and standard alloy steels to improve machinability for screw stock. Rollability of these steels on standard 60-deg threads is comparable to standard-analysis steels and in some cases better than unleaded B1100 series. Where severe displacement of metal takes place, as in steep sidewall or wide root-flat threads, some flaking may result.

Alloy Steels: Nickel of 3.25 to 3.75 per cent, as in 2330 or 2340 nickel steel, contributes to strength and ductility and makes a very suitable material for rolling, although the material is apt to be springy and requires more revolutions of the blank to obtain desired displacement. Because of greater tendency to work-harden, power requirements are slightly increased.

Manganese steels containing manganese of 1.5 to 2 per cent tend to have increased rolling resistance. However, the material rolls well and good finishes are obtained. Manganese steels behave very much the same as nickel steels.

Nickel-chromium structural steels, such as 3120 or 3140, containing 1 to 4 per cent nickel and 0.5 to 1.75 per cent chromium, are commonly used for shafts and various machinery parts. Threads on these parts may be rolled with very satisfactory finishes with pressure requirements similiar to those of nickel or manganese steels.

Molybdenum in the amounts of 0.15 to 0.3 per cent is usually combined with chromium or nickel to form high-grade structural alloy steels such as 4140, 4340, 4640 and 4820. This material is almost always used in the hardened state and very frequently rolling is done after heat-treatment. This steel rolls well, and pressures required depend largely upon hardness of the material at time of rolling.

Nitriding steels are suitable for rolling prior to nitriding and behave very similarly to molybdenum steels.

Stainless Steels: Stainless steels of the 400 series may be heat treated and, for the most part, do not work-harden as much as the 300 series. Rolling results in an excellent finish. However, considerable pressure is required and a slight to moderate seam in the crest may be detected.

The 300-series stainless steels work-harden rapidly and are harder to roll than the 400 series. Finishes obtained are excellent, but rolling loads are higher and die life expentancy is less than with the 400 series. No seam is produced at the crest; even incompletely rolled threads have smooth crests.

Nonferrous Metals: Among nonferrous materials available for rolling, copper and many copper-base alloys possess excellent cold-working properties and are good materials for rolling. Brasses, such as commercial bronze, cartridge brass and yellow brass, are preferred. Finish obtained is excellent and power to roll is a little less than for mild steel.

Inclusion of lead in brasses for improvement of machinability tends to cause slivering at crests of fine threads and flaking in roots of coarse threads with wide root flats. Although a minimum of 0.5 per cent lead is preferred for rolling, much rolling in screw machines is done on free-cutting brasses having a lead content as high as 3 per cent. Use of higher leaded brasses because of greater machining speeds or general availability may present certain problems, depending upon degree of finish required on the rolled thread.

Free-cutting brasses, with not more than 15 per cent area reduction to finish size after last anneal, are recommended as optimum for thread rolling. It is desirable that material be properly processed at the mill to minimize amount of beta structure which is hard, brittle, and detrimental to good rollability. Where free-cutting brass must be used,

orders for the material should stress that material is for thread rolling.

Commercially pure aluminum, such as 1100 and 3003, is soft and ductile and can be easily thread rolled. Due to its low strength and rather poor machining properties, aluminum is often alloyed with other elements to give it greater strength and improved cutting properties. The 2017 and 2024 alloys are commonly used for high-strength headed parts and are readily thread rolled. Alloying of aluminum and various hardening processes tend to decrease ductility, which in turn affects rollability. As far as possible, annealed or softer grades of these alloys are preferred for rolling. Heating aluminum alloys increases ductility and may be helpful when rolling low-ductility alloys.

Titanium: Recent demands for titanium fast-

Table 3—Nonferrous Alloys

Class	Common Name	Approx. Composition (per cent)	Rollability		Machinability
			Finish on Thread[1]	Relative Die Life[2]	
Copper					
	Electrolytic copper	99.9 Cu	E	H	20
	Oxygen-free copper	99.98 Cu, 0.02 P	E	H	20
	Arsenical copper	99.7 Cu, 0.3 As	E	H	20
	Phosphorized copper	99.97 Cu, 0.03 P	E	H	20
	Leaded copper (free machining)	99 Cu, 1 Pb	G	H	80
Copper-Zinc Alloys					
	Commercial bronze	90 Cu, 10 Zn	E	H	20
	Red brass	85 Cu, 15 Zn	E	H	30
	Fourdrinier	83 Cu, 17 Zn	E	H	30
	Low brass	80 Cu, 20 Zn	E	H	30
	Cartridge brass	70 Cu, 30 Zn	E	H	30
	Yellow brass, 66 per cent	66 Cu, 34 Zn	E	H	40
	Yellow brass, 62 per cent	62 Cu, 38 Zn	F-G	H	40
	Muntz metal	60 Cu, 40 Zn	F	H	40
Free-Cutting Copper-Zinc Alloys					
	Free-cutting brass	61.5 Cu, 35.5 Zn, 3 Pb	F	H	100
	High-leaded brass	62.5 Cu, 35.75 Zn, 1.75 Pb	F-G	H	90
	Medium-leaded brass	64.5 Cu, 34.5 Zn, 1 Pb	G-E	H	70
Tin Bronzes					
	Admiralty metal	71 Cu, 28 Zn, 1 Sn	E	H	30
	Naval brass	60.25 Cu, 39 Zn, 0.75 Sn	F-G	H	30
	Leaded naval brass	60.5 Cu, 36.75 Zn, 2 Pb, 0.75 Sn	P	H	70
	Tobin bronze	60 Cu, 39.25 Zn, 0.75 Sn	F-G	H	30
	Trumpet brass	81 Cu, 18 Zn, 1 Sn	E	H	20
Phosphor Bronzes					
	Phosphor bronze	95 Cu, 5 Sn, 0.1 P	E	H	30
	4% Phosphor bronze (Grade A)	95.75 Cu, 4 Sn, 0.25 P	E	H	20
	5% Phosphor bronze (Grade A)	95 Cu, 4.75 Sn, 0.25 P	E	H	20
	8% Phosphor bronze (Grade C)	92 Cu, 7.75 Sn, 0.25 P	G	H	20
	10% Phosphor bronze (Grade D)	89.5 Cu, 10.5 Sn	F	H	20
	Leaded phosphor bronze (Grade B)	94 Cu, 5 Sn, 1 Pb	F	H	50
	Free-cutting phosphor bronze	88 Cu, 4 Zn, 4 Sn, 4 Pb	F	H	90
Copper-Silicon Alloys					
	Everdur No. 1010 and 1015		E	M	30
	Everdur No. 1012		G	M	60
	Duronze I or 609		E	M	20
	Duronze II or 606		G	M	25
	Duronze III or 707		P	M	70
	Olympic Bronze A, B, and G		E	M	30
	Olympic Bronze D		G	M	60
	Herculoy No. 418 and 420		G	M	30
	Herculoy No. 419 and 421		E	M	30
Aluminum Bronze					
	5% Aluminum bronze	95 Cu, 5 Al	E	H	20
	8% Aluminum bronze	92 Cu, 8 Al	G	M	20
	Nickel-aluminum bronze		P	M	20
	5% Nickel-aluminum bronze		P	M	20
	Nickel-aluminum bronze (Type A)		E	H	20
	Nickel-aluminum bronze (Type B)		E	H	20
Cupronickels					
	15 and 20% Cupronickel		E	M	20
	30% Cupronickel		G	M	20
Nickel Silver					
	Nickel silver	55-75 Cu, 10-20 Ni, 5-27 Zn	E	H	20
	Leaded nickel silver	65 Cu, 22 Zn, 12 Ni, 1 Pb	G-F	M	50
	Extruded nickel silver	46.5 Cu, 40.75 Zn, 10 Ni, 2.75 Pb	P	M	80
Nickel and Nickel Alloys (Wrought)					
	Nickel "A"	99.4 Ni, 0.1 C	E	M	30
	Low-carbon nickel	99.4 Ni, 0.01 C	E	M	30
	D Nickel	4.65 Mn	E	M	30
	Z Nickel	Al	G	M	25
	Monel	70 Cu, 30 Ni	E	M	60
	R Monel	Monel + S	E	M	70
	K Monel	.....	E	M	30
	KR Monel	.....	G	M	70
	Inconel	Ni, Cr, Fe, Si	F	M	25
	Hastelloy A, B, and C	Ni, Mo, Fe	F	L	30
Titanium					
	AMS 4900	Commercially pure Ti	E-G	M-L	45
	AMS 49AA	90 Ti, 6 Al, 4 V	E-G	L	25
	AMS 4925	92 Ti, 4 Al, 4 Mn	E-G	L	25
Other Alloys					
	Phosnic bronze	98.7 Cu, 1.1 Ni, 0.2 P	E	H	..
	Tellurium copper	99.5 Cu, 0.5 Te	G	H	..
	Manganese bronze (A)	58.5 Cu, 1 Se, 1 Fe, 0.25 Mn, bal Zn	P	M	..
	Beryllium copper	97.6 Cu, 2.05 Be, 0.35 Ni	G	M	..
	Beryllium copper, hardened	97.6 Cu, 2.05 Be, 0.35 Ni	P	L	..

1. E=Excellent; G=Good; F=Fair; P=Poor.
2. H=High; M=Moderate; L=Low.

Table 4—Aluminum and Aluminum Alloys

Alloy Designation New	Alloy Designation Old	Tensile Yield Strength (psi)	Relative Ductility	Rollability: Finish on Thread[2]	Machinability Rating[3]	Notes
1100-O	2S-O	5,000	100	E	G	4
1100-H12	2S-¼H	13,000	55	E	G	4
1100-H14	2S-½H	14,000	45	E	G	4
1100-H16	2S-¾H	17,000	38	G	G	4
1100-H18	2S-H	21,000	33	G	G	4
3003-O	3S-O	6,000	89	E	G	4
3003-H12	3S-¼H	15,000	45	E	G	4
3003-H14	3S-½H	18,000	36	G	G	4
3003-H16	3S-¾H	21,000	31	F	G	4
3003-H18	3S-H	25,000	22	F	G	4
2011-T3	11S-T3	47,000	33	G-F	E	5
2011-T3	11S-T8	44,000	31	F	E	5
2014-O	14S-O	14,000	40	G	G	6
2014-W	14S-W	40,000	55	E	G	6
2014-T	14S-T	60,000	29	F	G	6
2017-O	17S-O	26,000	49	E	G	7
2017-T4	17S-T	62,000	49	E	E	
2117-T4	A17S-T	24,000	60	E	E	
2024-O	24S-O	11,000	49	E	G	8
2024-T4	24S-T	46,000	49	E	E	8
5052-O	52S-O	14,000	67	E	G	
5052-H32	52S-¼H	26,000	40	G	G	
5052-H34	52S-½H	29,000	31	F	G	
5052-H36	52S-¾H	34,000	22	F	G	
5052-H38	52S-H	36,000	18	P	G	
6053-O	53S-O	7,000	78	E	G	9
6053-T4	53S-W	20,000	67	E	G	9
6053-T6	53S-T	33,000	44	E	G	9
5056-O	56S-O	20,000	78	E	G	10
5056-H38	56S-H	48,000	15	P	G	10
6061-O	61S-O	8,000	49	E	G	
6061-T4	61S-W	21,000	49	E	G	
6061-T6	61S-T	39,000	27	F	G	
7075- O	75S-O	20,000	27	F	G	
7075-T6	75S-T	80,000	22	P	E	

1. Relative die life for all aluminum alloys is high.
2. E=Excellent; G=Good; F=Fair; P=Poor.
3. E=Excellent; G=Good.
4. Most suitable of the aluminum alloys for rolling where high tensile strength is not required.
5. Not ordinarily used for rolling.
6. High-strength alloys used in aircraft fittings.
7. Used for headed parts and rolled-thread fasteners.
8. Used for headed parts, rolled-thread fasteners, and aircraft fittings.
9. Good rolling material with high noncorrosive properties.
10. Magnesium included; suitable for rolling in soft stage.

eners have forced development of techniques for thread rolling this material. Most common alloys used in threaded fasteners are 4 Al; 4 Mn; and 6 Al, 4 V alloys. These alloys are about Rockwell 33 to 38 C hardness and workharden very rapidly. Titanium blanks should have excellent finish with no blemishes, scratches, or imperfections. Such defects will show up in rolled threads as laps or seams. Threads should have a radius at the roots.

Diecastings: Most popular zinc and aluminum-base diecast alloys permit thread rolling. Threads on most aluminum and zinc-base diecast alloys, such as Zamak 3, have excellent rolled finishes. Die life experienced in rolling diecastings is outstanding and makes rolling a most desirable method for threading. Since surface of a diecasting usually has a draft taper and is apt to crumble and flake during rolling, a machined blank surface is preferred for best size and control of finish.

Other Materials: Although the most commonly used materials have been listed, it is possible to roll other materials with varying results. These include: magnesium, zirconium, phenolic plastics, molybdenum, powdered metals, and vulcanized fiber.

ACKNOWLEDGEMENT

This is the final article in a group of three that form a comprehensive designer's manual on the thread and form-rolling process. The articles are based on *Engineering Data on Thread and Form Rolling,* soon to be published by Reed Rolled Thread Die Co., Worcester, Mass. The preceding articles, and the issues of MACHINE DESIGN in which they appeared, are:

"Thread Rolling" ..... December 26, 1957
"Form Rolling" ..... January 9, 1958

They Say . . .

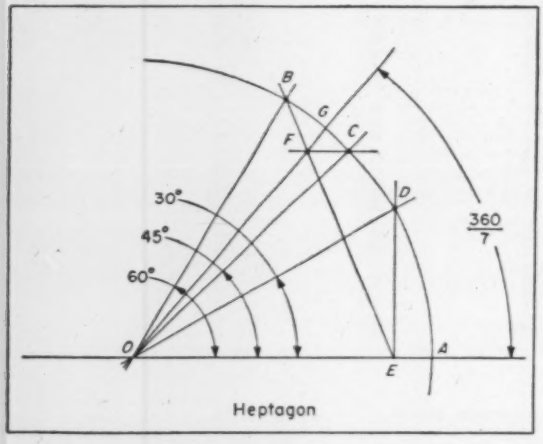
"The scarcity of (inventive) geniuses can be compensated partially by organizing teams of scientists and engineers to achieve less spectacular but steady advances in limited areas—but can these large teams recognize, and accommodate themselves, to the truly creative individual? The number of creative people available and the effective management of these people will determine progress to a much greater extent than will laboratory facilities and annual budgets." — MORROUGH P. O'BRIEN, *dean, College of Engineering, University of California, Berkeley, Calif.*

Tips and Techniques

Constructing Polygons

Simple geometric constructions permit laying out approximate, but very accurate, polygons with 7, 9, or 10 sides. A pentagon can readily be drawn by first constructing a decagon.

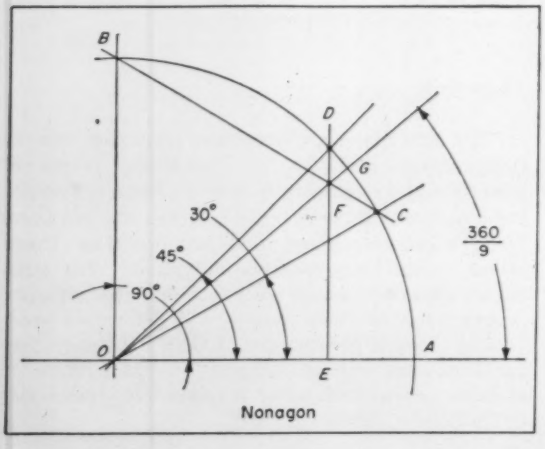
To Construct a Heptagon:



Heptagon

1. Draw reference radius, *OA*.
2. Draw radii, *OB*, *OC*, and *OD*, at angles of 60, 45, and 30 deg respectively with the reference radius.
3. From *D* draw a perpendicular to *OA*, intersecting *OA* at *E*.
4. Draw *BE*.
5. From *C* draw a line parallel to *OA*, intersecting *BE* at *F*.
6. Draw a line, *OF*, through the intersection to the circle at *G*.
7. *AG* is the arc over one side of a regular heptagon.

This construction is accurate to better than one part in approximately five hundred.



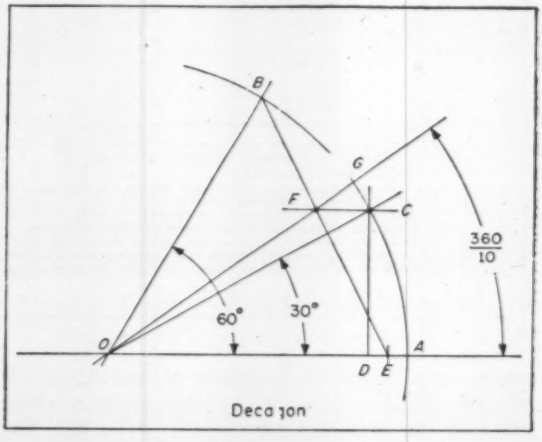
Nonagon

To Construct a Nonagon:

1. Draw reference radius, *OA*.
2. Draw radii, *OB*, *OC*, and *OD*, making angles of 90, 30, and 45 deg with the reference radius.
3. From *D* draw a perpendicular to *OA*, intersecting at point *E*.
4. Draw *BC*, intersecting *DE* at *F*.
5. Draw *OF*, through the intersection to the circle at *G*.
6. *AG* is the arc over one side of a regular nonagon.

This construction is accurate to about one part in eight hundred.

To Construct a Decagon:



Decagon

1. Draw reference radius, *OA*.
2. Draw radii *OB* and *OC*, making angles of 60 and 30 deg respectively with *OA*.
3. From *C* draw a perpendicular to *OA*, intersecting at *D*.
4. Locate point *E* at the midpoint of line segment *DA*.
5. Draw line *BE*.
6. From *C*, draw a line parallel to *OA*, intersecting *BE* at *F*.
7. Draw radius *OF*, through the intersection to the circle at *G*.
8. *AG* is the arc over one side of a regular decagon. From a regular decagon one can immediately construct a regular pentagon.

Accuracy of this construction is one part in two hundred. If *DE* is made 0.6 of *DA*, accuracy will be better than one part in two thousand.—JESSE ROTH, *electrical engineer, Curtiss-Wright Corp., Carlstadt, N. J.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Accurate control of

Mechanical Circuit Switching

By MAX FOGIEL
New York, N. Y.

IN AUTOMATIC-MACHINE applications, the closing of a mechanical switch to complete an electrical circuit is usually accomplished by a cam. As shown in the diagram, the cam actuates the roller of the harness which in turn depresses the switch.

Whenever only one cam is used and the range of the variable is large, it is not always possible to close the circuit within the required timing accuracy. With more than one cam, properly geared together, it is possible to arrange a circuit which will close within any desired accuracy.

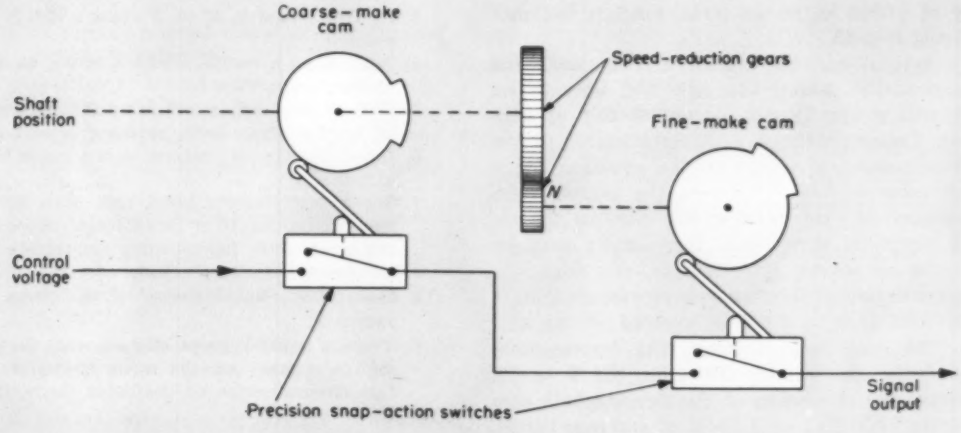
The accompanying diagram shows a two-cam system. Let δ deg of rotation represent the accuracy to which the fine-make cam can be set. If the permissible error is ε units, 360 deg of rotation or one revolution of the fine-make cam represents $360\varepsilon/\delta$ units.

The coarse-make cam must be accurate to within one revolution of the fine-make cam since it must recognize the number of revolutions of the fine-make cam. Since δ degrees of rotation also represents the accuracy to which the coarse-make cam can be set, 360 deg of rotation or one revolution of the coarse-make cam represents $\varepsilon(360/\delta)^2$ units.

The gear ratio N between cam shafts is therefore

$$N = \frac{\varepsilon\left(\frac{360}{\delta}\right)^2}{\frac{360\varepsilon}{\delta}} = \frac{360}{\delta}$$

If the number of units represented by one revolution of the coarse-make cam does not exceed the required range of the variable, three or more cam-and-switch combinations may be necessary. The number of units represented by one revolution



Switching circuitry and dual-cam actuation system for closing circuits within any given degree of accuracy.

of the nth cam is therefore $\varepsilon(360/\delta)^n$.

If the required range of the variable is R, its value is

$$R = \varepsilon \left(\frac{360}{\delta} \right)^n$$

where

$$n = \frac{\log \left(\frac{R}{\varepsilon} \right)}{\log \left(\frac{360}{\delta} \right)}$$

The value selected for n is the next larger integer.

If a signal is required to last for a given interval, two circuits as shown in the diagram may be combined to control a relay circuit or flip-flop. One switching arrangement may be employed to generate the setting signal which would place the relay circuit or flip-flop in the state that produces a signal marking the beginning of the interval. The other switching arrangement would then generate the resetting signal to return the relay circuit or flip-flop to its original state, thereby marking the end of the interval.

Although the illustration indicates a cam-operated switch to produce the required circuit closure, the preceding analysis may be applied to any general switching component which has an uncertainty associated with closing the circuit through it.

Example: To illustrate a practical application of the equations, assume that the coarse cam is mechanically connected to a lead screw so that when the lead screw rotates through one revolution, the coarse cam also rotates one revolution. Assume that the lead screw is employed to move a machine tool carriage over a distance of 60 in. Assume further, that the position of the machine's carriage must be registered by an electrical signal used for control purposes when the carriage is located 50 in. from its starting position. If the carriage position must be registered within an accuracy of 0.0005 in. at the 50-in. mark, ε becomes 0.0005 and R is 50.

In a typical cam-and-switch arrangement, the accuracy within which the cam will operate its switch will generally not exceed 5 deg of cam rotation. Consequently, $\delta = 5$. Substitution of the preceding numerical values in the equation for n gives a value of 2.69. Therefore the nearest integral number of cam units which includes the required range, is three. The three units may be designated as coarse, intermediate, and fine.

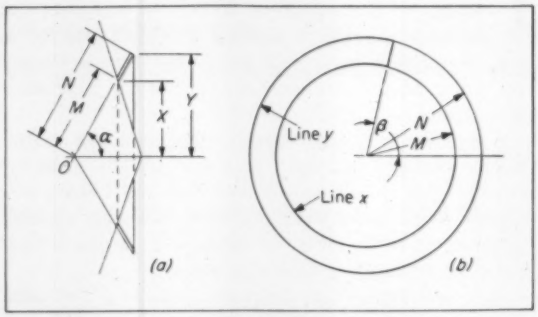
One revolution of the fine cam represents $360\varepsilon/\delta = 360(0.0005)/5 = 0.036$-in. motion of the carriage. The gear ratio between the intermediate cam and the fine cam is $360/\delta = 360/5 = 72$. Therefore, one revolution of the intermediate cam represents $0.036(72) = 2.59$-in. of carriage travel. The coarse cam is in turn geared to the intermediate cam through a ratio that is also 72. One revolution of the coarse cam thus represents $2.59(72) = 187$ in. which more than includes the required range of 50 in. This proves the premise that three cam units are required. Since the range of the intermediate cam is only 2.59 in. a third cam unit is necessary to include the required range of 50 inches.

This numerical example illustrates how relatively inaccurate cam and switch units may be employed to generate signals for accurate control.

Tips and Techniques

Layout of Conic Surface

When a conical part of specific dimensions must be constructed, a layout is required to save time and material. Design of a conical, sheet-metal part



for assembly to a matching machine part presents a typical layout problem which can be conveniently solved.

1. Select the desired position for the sheet-metal part on the tapered surface of the work, consistent with the design and clearance desired, view a.
2. After selecting radii X and Y, and angle α, extend the angle to point O on the center line.
3. By trigonometry, $M = X$ cosec α and $N = Y$ cosec α.
4. With M as a radius, scribe a circle, as shown on the layout, view b.
5. With N as a radius and using the same center as for the first circle, scribe a second circle.
6. Determine the circumference of a circle having a radius X.
7. Select any starting point and, with dividers, step off the length of this circumference along the inner circle, line x, using increments small enough for accurate results.
8. Determine circumference of a circle with radius Y.
9. From a starting point aligned with the starting point used on the inner circle, step off this circumference on the outer circle, line y.
10. By proportion,

$$\beta = 360 - 360 \left(\frac{\pi 2X}{\pi 2Y} \right)$$

—GEORGE DAVID PHEIL, *Racine, Wis.*

How to find exact values of

Backlash in Spur Gears

for changes in tooth thickness or center distance

By RICHARD L. THOEN
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Backlash calculations are commonly based upon a mathematical approximation that heretofore has generally yielded sufficient accuracy. With increased emphasis on backlash control in precision gear trains, a more exact calculation procedure becomes necessary. Tables presented here provide a precise and convenient method.

Nomenclature

$B_{\phi 1}$ = Operating angular backlash with respect to gear 1, rad
$B_{\phi 2}$ = Operating angular backlash with respect to gear 2, rad
B_b = Operating backlash on line of action, in.
B = Total circular backlash, in.
$= B_b \sec \phi_s = N_1 B_{\phi 1}/2P = N_2 B_{\phi 2}/2P$
C = Standard center distance, in.
$= (N_1 + N_2)/2P$
ΔC = Difference between operating and standard center distances, in.
N_1 = Number of teeth on gear 1
N_2 = Number of teeth on gear 2
P = Diametral pitch
T_1 = Circular tooth thickness of gear 1 at radius $N_1/2P$, in.
T_2 = Circular tooth thickness of gear 2 at radius $N_2/2P$, in.
ΔT_1 = Difference between operating and standard circular tooth thicknesses of gear 1, in.
$= T_1 - (\pi/2P)$
ΔT_2 = Difference between operating and standard circular tooth thicknesses of gear 2, in.
$= T_2 - (\pi/2P)$
ΔT = Total circular tooth thickness difference, including backlash, in.
$= \Delta T_1 + \Delta T_2 + B$
ϕ = Operating pressure angle, deg
ϕ_s = Standard pressure angle, deg

IN the design and measurement of spur gears it is customary to compute changes in tooth thickness, backlash, and center distance[1] from

$$\frac{\Delta T}{\Delta C} \approx 2 \tan \phi_s \qquad (1)$$

and

$$\frac{\Delta C}{\Delta T} \approx \frac{1}{2 \tan \phi_s} \qquad (2)$$

which, in most cases, are good approximations.

However, Equations 1 and 2 are special cases of the infinite series,

$$\frac{\Delta T}{\Delta C} = 2 \tan \phi_s + \frac{1}{\tan \phi_s} \frac{\Delta C}{C} - \frac{1 + 3 \tan^2 \phi_s}{3 \tan^3 \phi_s} \left(\frac{\Delta C}{C} \right)^2 + \ldots \qquad (3)$$

and

$$\frac{\Delta C}{\Delta T} = \frac{1}{2 \tan \phi_s} - \frac{1}{8 \tan^4 \phi_s} \frac{\Delta T}{C} + \frac{4 + 3 \tan^2 \phi_s}{48 \tan^7 \phi_s} \left(\frac{\Delta T}{C} \right)^2 - \ldots \qquad (4)$$

From Equations 3 and 4, it can be seen that Equations 1 and 2 are exact only when C is infinitely large, as is the case when a gear meshes with a rack.

For 20-deg pressure angle, Equations 3 and 4 become

$$\frac{\Delta T}{\Delta C} = 0.7279 + 2.75 \frac{\Delta C}{C} - \left(3.1 \frac{\Delta C}{C} \right)^2 + \ldots \qquad (3a)$$

and

$$\frac{\Delta C}{\Delta T} = 1.374 - 7.12 \frac{\Delta T}{C} + \left(10 \frac{\Delta T}{C} \right)^2 - \ldots \qquad (4a)$$

And, for 14½-deg pressure angle,

[1]References are tabulated at end of article.

(*Text continued on Page* 150)

Table 1—$\Delta T/\Delta C$ Factors Vs. $\Delta C/C$

$\frac{\Delta C}{C}$	$\frac{\Delta T}{\Delta C}$	Diff	$\frac{\Delta C}{C}$	$\frac{\Delta T}{\Delta C}$	Diff	$\frac{\Delta C}{C}$	$\frac{\Delta T}{\Delta C}$	Diff	$\frac{\Delta C}{C}$	$\frac{\Delta T}{\Delta C}$	Diff	$\frac{\Delta C}{C}$	$\frac{\Delta T}{\Delta C}$	Diff
20-Deg Pressure Angle														
			−.0200	.6686		+.0010	.7307		+.0210	.7818		+.0420	.8295	
					32			27			24			43
			−.0190	.6718		+.0020	.7334		+.0220	.7842		+.0440	.8338	
					32			27			24			42
			−.0180	.6750		+.0030	.7361		+.0230	.7866		+.0460	.8380	
					31			27			24			42
			−.0170	.6781		+.0040	.7388		+.0240	.7890		+.0480	.8422	
					31			26			24			42
			−.0160	.6812		+.0050	.7414		+.0250	.7914		+.0500	.8464	
					31			27			23			41
			−.0150	.6843		+.0060	.7441		+.0260	.7937		+.0520	.8505	
					31			26			23			41
−.0340	.6202		−.0140	.6874		+.0070	.7467		+.0270	.7960		+.0540	.8546	
		37			31			26			23			40
−.0330	.6239		−.0130	.6905		+.0080	.7493		+.0280	.7983		+.0560	.8586	
		38			30			26			23			40
−.0320	.6275		−.0120	.6935		+.0090	.7519		+.0290	.8006		+.0580	.8626	
		36			30			26			23			40
−.0310	.6311		−.0110	.6965		+.0100	.7545		+.0300	.8029		+.0600	.8666	
		36			29			26			23			39
−.0300	.6347		−.0100	.6994		+.0110	.7571		+.0310	.8052		+.0620	.8705	
		36			30			25			23			39
−.0290	.6383		−.0090	.7024		+.0120	.7596		+.0320	.8075		+.0640	.8744	
		35			29			26			22			38
−.0280	.6418		−.0080	.7053		+.0130	.7622		+.0330	.8097		+.0660	.8782	
		35			29			25			23			38
−.0270	.6453		−.0070	.7082		+.0140	.7647		+.0340	.8120		+.0680	.8820	
		34			29			25			22			38
−.0260	.6487		−.0060	.7111		+.0150	.7672		+.0350	.8142		+.0700	.8858	
		34			29			24			22			38
−.0250	.6521		−.0050	.7140		+.0160	.7696		+.0360	.8164		+.0720	.8896	
		34			28			25			22			37
−.0240	.6555		−.0040	.7168		+.0170	.7721		+.0370	.8186		+.0740	.8933	
		33			28			25			22			37
−.0230	.6588		−.0030	.7196		+.0180	.7746		+.0380	.8208		+.0760	.8970	
		33			28			24			22			37
−.0220	.6621		−.0020	.7224		+.0190	.7770		+.0390	.8230		+.0780	.9007	
		32			28			24			22			36
−.0210	.6653		−.0010	.7252		+.0200	.7794		+.0400	.8252		+.0800	.9043	
		33			27			24			43			36
−.0200	.6686		.0000	.7279		+.0210	.7818		+.0420	.8295		+.0820	.9079	
					28									
14½-Deg Pressure Angle														
			−.0100	.4759		+.0005	.5192		+.0105	.5556		+.0210	.5901	
					22			19			17			31
			−.0095	.4781		+.0010	.5211		+.0110	.5573		+.0220	.5932	
					22			19			17			31
			−.0090	.4803		+.0015	.5230		+.0115	.5590		+.0230	.5963	
					22			19			17			31
			−.0085	.4825		+.0020	.5249		+.0120	.5607		+.0240	.5994	
					21			19			17			30
			−.0080	.4846		+.0025	.5268		+.0125	.5624		+.0250	.6024	
					22			18			17			31
−.0175	.4405		−.0075	.4868		+.0030	.5286		+.0130	.5641		+.0260	.6055	
		25			21			19			17			30
−.0170	.4430		−.0070	.4889		+.0035	.5305		+.0135	.5658		+.0270	.6085	
		25			21			19			16			30
−.0165	.4455		−.0065	.4910		+.0040	.5324		+.0140	.5674		+.0280	.6115	
		25			21			18			17			29
−.0160	.4480		−.0060	.4931		+.0045	.5342		+.0145	.5691		+.0290	.6144	
		24			21			18			17			30
−.0155	.4504		−.0055	.4952		+.0050	.5360		+.0150	.5708		+.0300	.6174	
		24			21			18			16			29
−.0150	.4528		−.0050	.4973		+.0055	.5378		+.0155	.5724		+.0310	.6203	
		24			20			19			17			29
−.0145	.4552		−.0045	.4993		+.0060	.5397		+.0160	.5741		+.0320	.6232	
		24			21			18			16			28
−.0140	.4576		−.0040	.5014		+.0065	.5415		+.0165	.5757		+.0330	.6260	
		24			20			18			16			29
−.0135	.4600		−.0035	.5034		+.0070	.5433		+.0170	.5773		+.0340	.6289	
		23			20			17			16			28
−.0130	.4623		−.0030	.5054		+.0075	.5450		+.0175	.5789		+.0350	.6317	
		23			20			18			17			28
−.0125	.4646		−.0025	.5074		+.0080	.5468		+.0180	.5806		+.0360	.6345	
		23			20			18			16			28
−.0120	.4669		−.0020	.5094		+.0085	.5486		+.0185	.5822		+.0370	.6373	
		23			20			17			16			28
−.0115	.4692		−.0015	.5114		+.0090	.5503		+.0190	.5838		+.0380	.6401	
		22			19			18			16			27
−.0110	.4715		−.0010	.5134		+.0095	.5521		+.0195	.5854		+.0390	.6428	
		22			19			17			15			28
−.0105	.4737		−.0005	.5153		+.0100	.5538		+.0200	.5869		+.0400	.6456	
					19			18			32			27
−.0100	.4759		.0000	.5172		+.0105	.5556		+.0210	.5901		+.0410	.6483	
					20									

Table 2—$\Delta C/\Delta T$ Factors Vs. $\Delta T/C$

$\frac{\Delta T}{C}$	$\frac{\Delta C}{\Delta T}$	Diff	$\frac{\Delta T}{C}$	$\frac{\Delta C}{\Delta T}$	Diff	$\frac{\Delta T}{C}$	$\frac{\Delta C}{\Delta T}$	Diff	$\frac{\Delta T}{C}$	$\frac{\Delta C}{\Delta T}$	Diff	$\frac{\Delta T}{C}$	$\frac{\Delta C}{\Delta T}$	Diff
20-Deg Pressure Angle														
			−.0150	1.516	6	+.0010	1.367	7	+.0220	1.254	8	+.0620	1.129	5
			−.0145	1.510	7	+.0020	1.360	7	+.0240	1.246	8	+.0640	1.124	4
			−.0140	1.503	6	+.0030	1.353	6	+.0260	1.238	8	+.0660	1.120	5
			−.0135	1.497	6	+.0040	1.347	7	+.0280	1.230	7	+.0680	1.115	4
			−.0130	1.491	5	+.0050	1.340	6	+.0300	1.223	8	+.0700	1.111	5
			−.0125	1.486	6	+.0060	1.334	6	+.0320	1.215	7	+.0720	1.106	4
			−.0120	1.480	6	+.0070	1.328	5	+.0340	1.208	6	+.0740	1.102	4
			−.0115	1.474	5	+.0080	1.323	6	+.0360	1.202	7	+.0760	1.098	
−.0210	1.611	10	−.0110	1.469	5	+.0090	1.317	6	+.0380	1.195	6			
−.0205	1.601	9	−.0105	1.464	5	+.0100	1.311	5	+.0400	1.189	7			
−.0200	1.592	9	−.0100	1.459	10	+.0110	1.306	5	+.0420	1.182	6			
−.0195	1.583	8	−.0090	1.449	10	+.0120	1.301	5	+.0440	1.176	5			
−.0190	1.575	8	−.0080	1.439	9	+.0130	1.296	5	+.0460	1.171	6			
−.0185	1.567	8	−.0070	1.430	9	+.0140	1.291	5	+.0480	1.165	6			
−.0180	1.559	8	−.0060	1.421	9	+.0150	1.286	5	+.0500	1.159	5			
−.0175	1.551	7	−.0050	1.412	8	+.0160	1.281	5	+.0520	1.154	5			
−.0170	1.544	8	−.0040	1.404	8	+.0170	1.276	4	+.0540	1.149	5			
−.0165	1.536	7	−.0030	1.396	8	+.0180	1.272	5	+.0560	1.144	5			
−.0160	1.529	7	−.0020	1.388	7	+.0190	1.267	4	+.0580	1.139	5			
−.0155	1.522	6	−.0010	1.381	7	+.0200	1.263	9	+.0600	1.134	5			
−.0150	1.516		0000	1.374	7	+.0220	1.254		+.0620	1.129				
14½-Deg Pressure Angle														
			−.0040	2.069	9	+.0002	1.928	6	+.0075	1.770	9	+.0250	1.556	9
−.0078	2.278	15	−.0038	2.060	8	+.0004	1.922	5	+.0080	1.761	8	+.0260	1.547	8
−.0076	2.263	15	−.0036	2.052	7	+.0006	1.917	5	+.0085	1.753	8	+.0270	1.539	
−.0074	2.248	14	−.0034	2.045	8	+.0008	1.912	6	+.0090	1.745	8			
−.0072	2.234	13	−.0032	2.037	7	+.0010	1.906	5	+.0095	1.737	8			
−.0070	2.221	12	−.0030	2.030	8	+.0012	1.901	5	+.0100	1.729	15			
−.0068	2.209	12	−.0028	2.022	7	+.0014	1.896	5	+.0110	1.714	14			
−.0066	2.197	12	−.0026	2.015	7	+.0016	1.891	5	+.0120	1.700	14			
−.0064	2.185	11	−.0024	2.008	7	+.0018	1.886	4	+.0130	1.686	13			
−.0062	2.174	11	−.0022	2.001	6	+.0020	1.882	12	+.0140	1.673	13			
−.0060	2.163	11	−.0020	1.995	7	+.0025	1.870	12	+.0150	1.660	12			
−.0058	2.152	10	−.0018	1.988	7	+.0030	1.858	11	+.0160	1.648	11			
−.0056	2.142	10	−.0016	1.981	6	+.0035	1.847	11	+.0170	1.637	12			
−.0054	2.132	10	−.0014	1.975	6	+.0040	1.836	10	+.0180	1.625	11			
−.0052	2.122	10	−.0012	1.969	6	+.0045	1.826	10	+.0190	1.614	10			
−.0050	2.112	9	−.0010	1.963	6	+.0050	1.816	10	+.0200	1.604	10			
−.0048	2.103	9	−.0008	1.957	6	+.0055	1.806	9	+.0210	1.594	10			
−.0046	2.094	9	−.0006	1.951	6	+.0060	1.797	9	+.0220	1.584	10			
−.0044	2.085	8	−.0004	1.945	6	+.0065	1.788	9	+.0230	1.574	9			
−.0042	2.077	8	−.0002	1.939	6	+.0070	1.779	9	+.0240	1.565	9			
−.0040	2.069		0000	1.933	5	+.0075	1.770		+.0250	1.556				

$$\frac{\Delta T}{\Delta C} = 0.5172 + 3.87\frac{\Delta C}{C} - \left(4.8\frac{\Delta C}{C}\right)^2 + \ldots \quad (3b)$$

and

$$\frac{\Delta C}{\Delta T} = 1.933 - 27.9\frac{\Delta T}{C} + \left(34\frac{\Delta T}{C}\right)^2 - \ldots \quad (4b)$$

It should be noted that the error in Equation 1 (or 2) can be significant if the numerical value of the second term in Equation 3 (or 4) is significant. Likewise, the error in Equation 3 (or 4) can be significant if the numerical value of its third term is significant. Additional terms would extend the working range of Equations 3 and 4, but for large values of $\Delta C/C$ and $\Delta T/C$ it is easier to obtain the $\Delta T/\Delta C$ and $\Delta C/\Delta T$ factors from tables. Such tables are presented in this article, Tables 1 and 2, for both 20-deg and 14½-deg pressure angles.

They are based upon the following exact equations by Candee:[2]

$$\sec\phi = \left(1 + \frac{\Delta C}{C}\right)\sec\phi_s \quad (5)$$

$$\text{inv}\,\phi = \text{inv}\,\phi_s + \frac{\Delta T}{2C} \quad (6)$$

$$\frac{\Delta T}{\Delta C} = 2\frac{\text{inv}\,\phi - \text{inv}\,\phi_s}{\sec\phi - \sec\phi_s}\sec\phi_s \quad (7)$$

For internal gears, a negative sign should be attached to each ΔT in the foregoing equations and Tables 1 and 2.

Example: Let $N_1 = 13$, $N_2 = 24$, $P = 64$, $\phi_s = 20$ deg, $\Delta T_1 = +0.00618$ in. and $\Delta T_2 = -0.00063$ in. Find the operating center distance for no backlash ($B = 0$). Thus, from the Nomenclature,

$$\Delta T = 0.00618 - 0.00063 + 0 = 0.00555 \text{ in.}$$

and

$$C = \frac{13 + 24}{2(64)} = 0.28906 \text{ in.}$$

From these two terms,

$$\frac{\Delta T}{C} = \frac{0.00555}{0.289} = 0.0192$$

Then, from the 20-deg portion of Table 2 for $\Delta T/C = 0.0192$ (interpolation between $+0.0190$ and $+0.0200$), $\Delta C/\Delta T = 1.266$, or

$$\Delta C = 1.266(\Delta T) = 1.266(0.00555) = 0.00703 \text{ in.}$$

Thus, the operating center distance is

$$C + \Delta C = 0.28906 + 0.00703 = 0.29609 \text{ in.}$$

As a matter of interest, the operating center distance will be calculated from Equations 4*a* and 2. From Equation 4*a*,

$$\frac{\Delta C}{\Delta T} = 1.374 - 7.12(0.0192) + [10(0.0192)]^2 - \ldots$$

$$= 1.374 - 0.137 + 0.037 = 1.274$$

and

$$\Delta C = 1.274(\Delta T) = 1.274(0.00555) = 0.00707 \text{ in.}$$

Thus, by this method, the operating center distance is

$$C + \Delta C = 0.28906 + 0.00707 = 0.29613 \text{ in.}$$

Or, Equation 4*a* produces an error of 0.00004 in.

Now, from Equation 2,

$$\frac{\Delta C}{\Delta T} = 1.374$$

and

$$\Delta C = 1.374(\Delta T) = 1.374(0.00555) = 0.00763 \text{ in.}$$

Thus, by the simple formula, the operating center distance is

$$C + \Delta C = 0.28906 + 0.00763 = 0.29669 \text{ in.}$$

Or, Equation 2 produces an error of 0.00060 in.

Note that the second term in Equation 4*a* is significant. Also, a mental calculation with the second term would show that the error in ΔC is approximately $7(\Delta T)^2/C = 7(0.006)^2/0.3 = 0.0008$ in.

REFERENCES

1. *Inspection of Fine-Pitch Gears*, AGMA 236.04; Par. 38, 119, 120; Table 10; Appendix A.
2. Allan H. Candee—"Involute Gear Calculations Simplified," *American Machinist*, September 13, 1945, pp. 122-128.

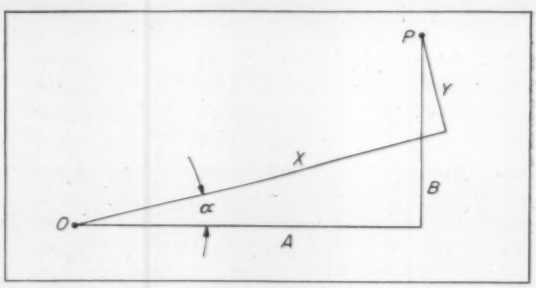
Tips and Techniques

Converting Co-ordinates

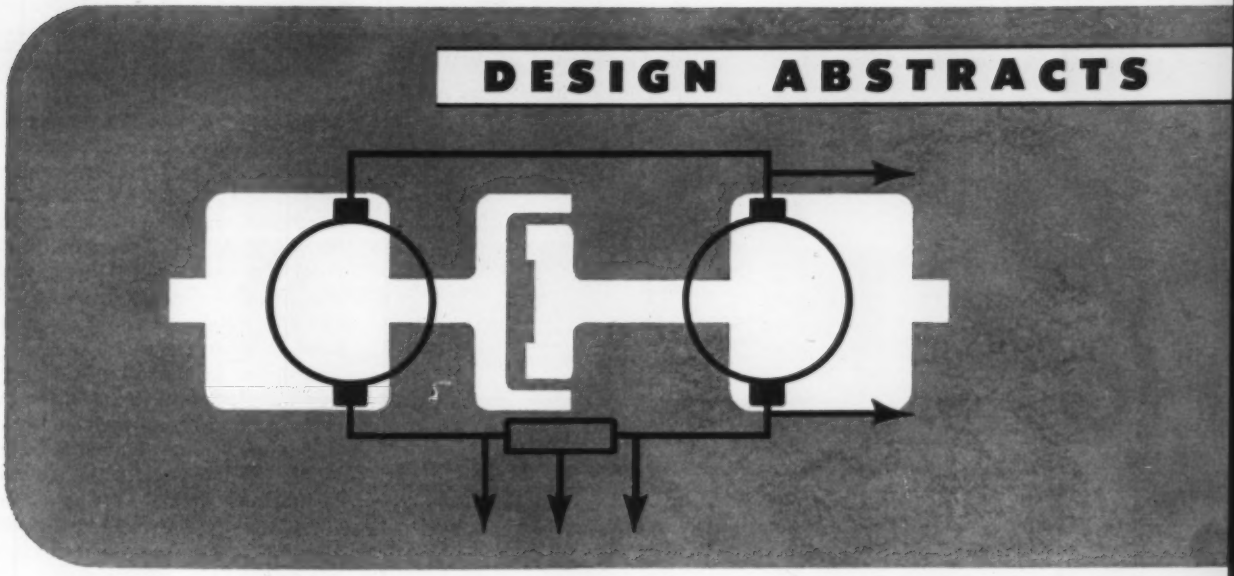
Redimensioning of hole and point locations to accommodate new reference angles can be done with a minimum of calculating and maximum accuracy. Assume lines A and B are co-ordinates of a point, P, with respect to point O, and reference axes change by an angle α. Co-ordinates on the new basis, X and Y, can be found from:

$$X = A\cos\alpha + B\sin\alpha$$

$$Y = B\cos\alpha - A\sin\alpha$$



Care must be used in handling signs of A, B, and α (α and sin α are positive when rotation is counterclockwise, as in sketch, and negative when clockwise).—MORTON P. MATTHEW, *Norwalk, Conn.*



DYNAMOMETERS

- application
- operation
- control

Flexibility and accuracy of the dynamometer have been greatly increased by application of precision instrumentation for measurements of speed and torque, use of programming methods for automatic control during test cycles, and development of interlock systems for safety of equipment and personnel. An overall dynamometer facility utilizes mechanical, pneumatic, hydraulic, electrical, and electronic components. Because of its complexity, those responsible for dynamometer performance must be familiar with types of dynamometers available and their applications; instrumentation necessary for measuring speed and torque; and factors governing the satisfactory performance of the complete facility.

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Detroit, Mich.

DYNAMOMETERS available today can be categorized as to the function they perform, their design and construction, and the types of devices they test.

The category of dynamometers in regard to function performed includes the absorber dynamometer, which absorbs power from the device being tested, and the motoring, or driving, dynamometer, which delivers rotative power to the device being tested.

Dynamometers categorized by design and construction include the inductor, or eddy current, dynamometer, the direct current dynamometer, and the combination, or universal, dynamometer, Fig. 1. An inductor dynamometer, *a*, consists of a solid ferrous rotor which turns in a magnetic field produced by dc current in a coil wound inside a ferrous stator. Rotation produces a pulsating magnetic field in the rotor teeth, thereby inducing eddy currents. These induced currents develop a second magnetic field in the rotor teeth which reacts with the field in the stator and produces torque. The direct current dynamometer, *b*, is a dc motor with separately excited armature and field. It can absorb or deliver power. Torque is produced by reaction between two magnetic fields and is limited by the cooling capacity of internally mounted fans. Speed is lim-

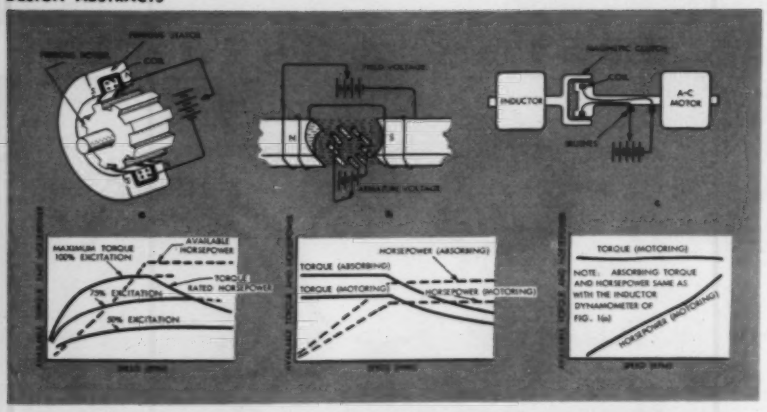


Fig. 1—Three basic dynamometer designs and operating characteristics. Eddy-current brake dynamometer, *a*, consists of a solid ferrous rotor, either slotted or smooth depending upon speed requirements. Torque is produced by an induced eddy-current field which reacts with the stator field. Direct-current dynamometer, *b*, produces torque by reaction between two magnetic fields, one from the dynamometer field and the other developed by current in the armature conductors. Universal dynamometer, *c*, consists of an inductor and ac motor coupled to the same shaft by a magnetic clutch.

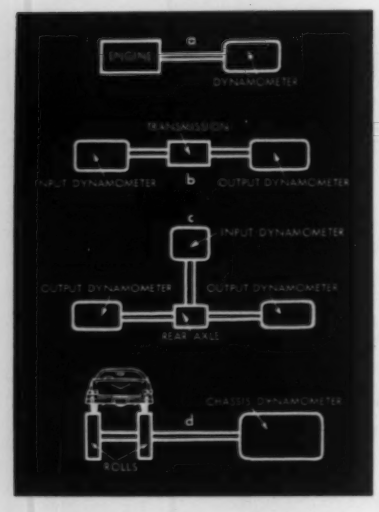
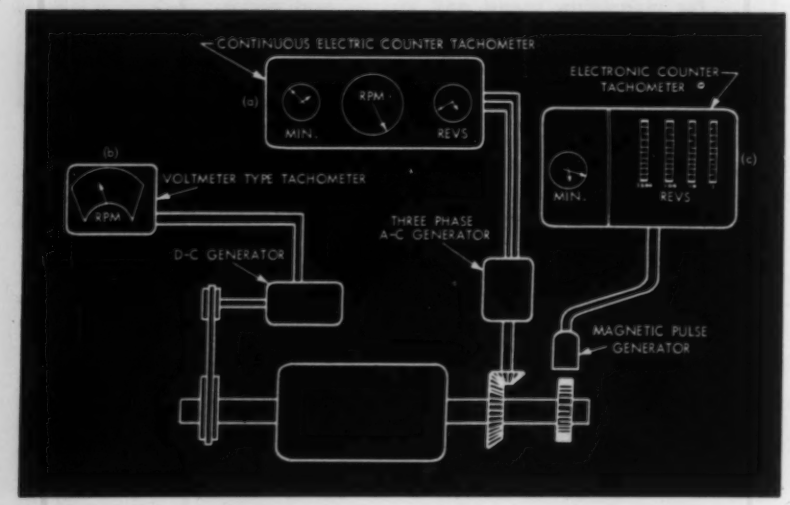


Fig. 2—Dynamometer types according to devices tested. Engine dynamometers, *a*, are used to establish speed-torque and horsepower characteristics of rotating-shaft machines. Two dynamometers, *b*, one for input (motoring) and one for output (absorbing), are used to test transmission designs for efficiency, life, output speed, torque, and slippage under various loads. Three dynamometers, *c*, are used for similar tests on rear axles. Chassis dynamometer, *d*, tests performance under simulated environmental conditions.

Fig. 3—Three most commonly used counters for measuring dynamometer speed connected to the same shaft for comparison. Continuous electric counter, *a*, consists of an eddy-current slip disc, a revolution counter, and precision electric timer. Accuracies of ± 10 rpm are possible. Voltmeter tachometer, *b*, is the simplest method of speed measurement. Accuracies of ±2 per cent f.i.r. are possible. Electronic tachometer, *c*, is the most accurate. To obtain continuous speed readings, a dc voltmeter is often used here.



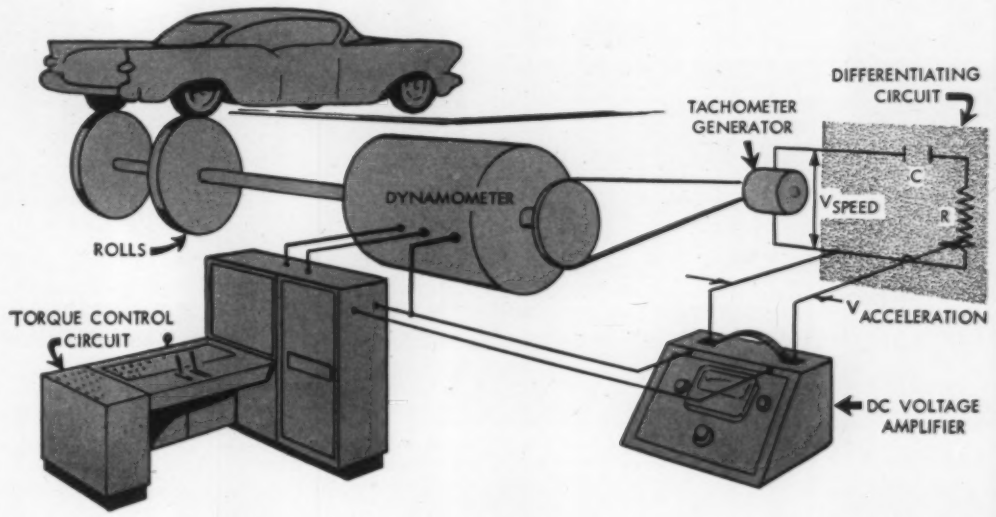
ited by the ability of the rotor components to stay together. The combination, or universal, dynamometer, *c*, consists of an inductor and an ac motor coupled to the same shaft through a magnetic clutch. When absorbing, the magnetic clutch is de-energized, disengaging the ac motor shaft from the absorber. When motoring, the absorber field is turned off and the magnetic clutch is energized to produce desired control.

Included in the classification of types of devices tested are, for example, the engine dynamometer, transmission dynamometer, rear axle dynamometer, and chassis dynamometer, Fig. 2. Any of the three basic dynamometer designs, Fig. 1, can be used to test internal-combustion, free-piston, and gas-turbine engines; motors, or pumps.

Accuracy of the calculated value for horsepower depends upon accuracy of speed and torque measurements taken during a test. Various types of instrumentation and methods are available for measuring speed and torque.

Speed Measurement: Instruments available for speed measurement include the stroboscope, hand speed-indicator, frequency meter, continuous electric counter, dc voltmeter-type tachometer, and electronic-counter tachometer. The latter three are most commonly used, Fig. 3. Electronic counter, *c*, is the most accurate speed measuring device. This device has the characteristic that its readings are either within plus or minus one count or are so far off as to be noted quickly. The actuating device consists of a pulse generator with its magnetic field interrupted by teeth on a gear or serrated cylinder attached or geared to the dynamometer shaft. An electronic counter displays speed readings intermittently. Revolutions may be counted for any length of time by using the electronic counter in conjunction with a precision electric timer.

Torque Measurement: Speed can be measured to an accuracy of ±1 rpm or better. The limiting factor, therefore, in accurate horsepower determination is measurement of torque. Dynamometer torque is measured by having the torque



Torque control of a dynamometer modified by auxiliary controls to simulate actual operating conditions. Inertia effect of the mass of an automobile, for example, is reproduced here electronically. A dc voltage proportional to speed from the tach generator is differentiated to produce a small dc voltage proportional to car acceleration. Amplified by a dc amplifier, this signal is used to modify the torque control circuit to produce a torque proportional to car acceleration. Inertia effect can also be simulated mechanically.

arm, attached to the cradle dynamometer stator, exert a force on some type of weighing system.

Trunnion, or cradle, bearings allow the stator of a dynamometer free, limited movement which permits torque on the stator to be measured. The most important source of error in torque measurement is trunnion bearing friction. Ball bearings minimize this source of error to some extent, but oil-floated trunnion bearings reduce it even further.

The next most important source of error in torque measurement is due to torque from pedestal-mounted accessories, such as a tachometer generator, by-passing the weighing system. By cradle mounting such accessories, their torque absorption can be measured. Other sources of torque leakage include stiff electric cables and cooling-water pressure changes. Cooling-water piping should be arranged to direct the water toward the centerline of the dynamometer. Any forces due to

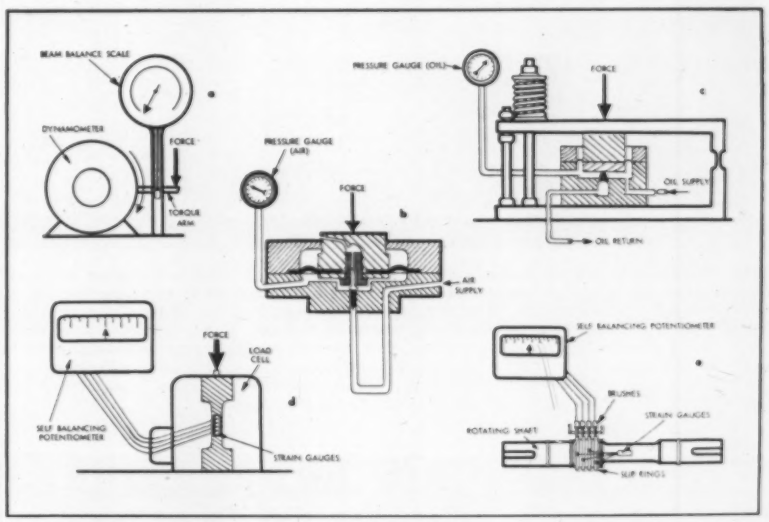


Fig. 4—Torque-measuring systems. Mechanical type, *a*, is the springless scale connected through a load-reversing lever system to the dynamometer torque arm. Pneumatic type, *b*, meters just enough air from a controlled-pressure supply into its diaphragm chamber to balance the torque-arm force by some pressure times an effective diaphragm area. Hydraulic torque-measuring system, *c*, balances torque-arm force with some value of pressure times an effective diaphragm area. With strain gage load cell, *d*, load from the torque arm is exerted on a load cell consisting of strain gages bonded to a load column. Voltage output is fed to an indicating and/or recording instrument. Shaft-mounted strain gage torquemeter, *e*, measures torque directly by using strain gages bonded to a shaft mounted between the engine crank shaft and absorber shaft.

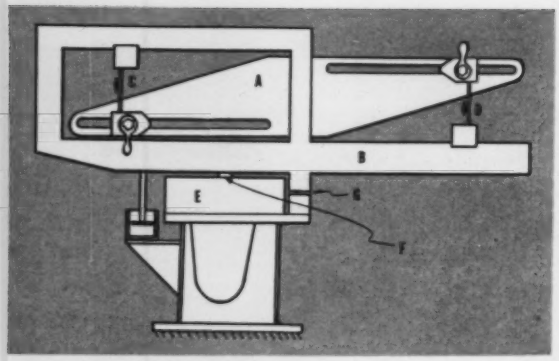


Fig. 5—A load-reversing mechanism. This mechanism enables motoring and absorbing dynamometer loads to be measured with a single-direction weighing transducer and permits unloading of the weighing system by means of an air operated cylinder, Fig. 6, to rezero the indicating dial. It is shown on a pneumatic load cell, but has been adapted for use with the electric and the two hydraulic cells of Fig. 4. Parallelogram *A* is attached to the dynamometer torque arm. Absorbing loads are transmitted to load arm *B* by cable *C*. Motoring loads are transmitted by cable *D*. Both absorbing and motoring loads exert a downward force on load cell *E* at *F* about fulcrum *G*.

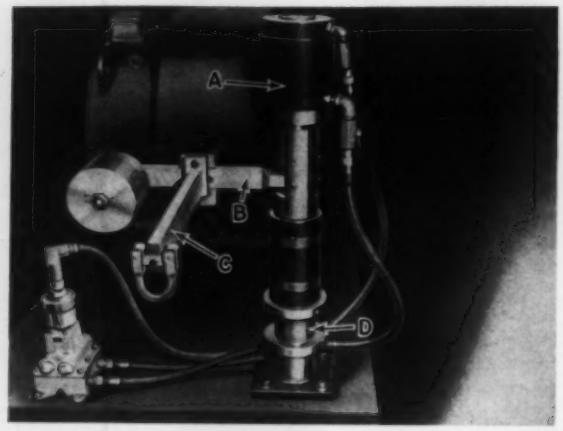


Fig. 6—Dynamometer-torque weighing systems unloaded by an air-operated cylinder. Cylinder *A* exerts a clamping force from both directions on member *B* attached to dynamometer torque arm *C*. The system shown is a modification of the one supplied with the dynamometer. The modification made the locking position more reproducible, and adjustment by means of turnbuckle *D*, easier.

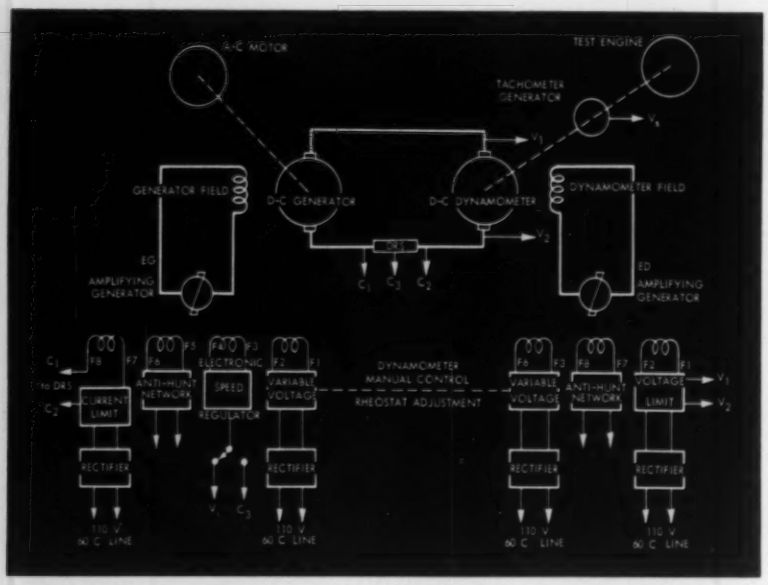


Fig. 7—A typical control system used on dc dynamometers. Speed or torque delivered to or absorbed by the dynamometer is controlled by dynamometer armature current or dynamometer field current. Armature current is regulated by controlling generator field voltage. Increasing dynamometer armature voltage, V_1-V_2, or decreasing dynamometer field voltage, increases speed. For manual control, generator field voltage and dynamometer field voltage are set by a rheostat adjustment to values producing required speeds at given load conditions. When load changes, speed changes to some extent because no feedback control signal is used.

pressure changes will then act at a zero torque arm and will not cause zero shift in the torque weighing system.

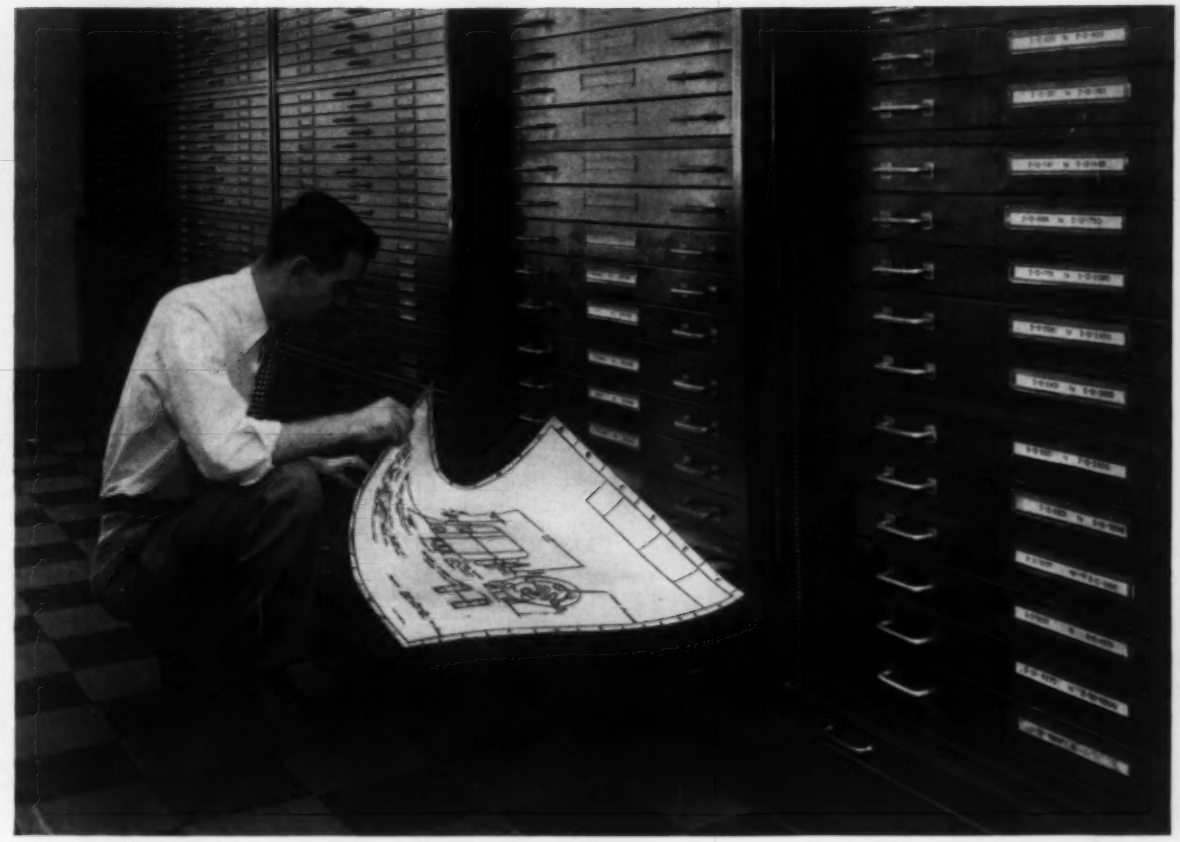
When factors affecting accurate torque measurement are reduced to negligible amounts, the remaining consideration is the accuracy of the torque weighing system. The weighing system used may be mechanical, pneumatic, hydraulic, or electric, Fig. 4.

Calibration of Torque-Weighing System: Calibration can be made using standard weights correctable to grains and checking torque arm distances correct to ±0.002 in. Correctable accuracy then reduces to the ability of the weighing system to repeat its reading. Repeatability of 0.1 per cent full scale reading is not at all uncommon on dynamometer torque-weighing systems. Accuracies to within ±0.5 per cent or better of full scale reading can be obtained.

To check and adjust torque system zero shift, the torque-weighing system is first unloaded and the dial then rezeroed. The mechanical weighing system using the springless beam scale has a linkage system permitting unloading. Any of the remote reading types of torque-weighing systems, Fig. 4, can be connected to the dynamometer through a load reversing mechanism, Fig. 5. Such a mechanism allows loads in either direction to be measured as well as making unloading possible. Actual unloading is accomplished by the force of an air-operated cylinder exerted on the dynamometer cradled stator, Fig. 6.

Dynamometer Control Systems: A dynamometer is only as useful as its control system is flexible. Careful consideration must be given to the method of dynamometer control, both manual and automatic, so that tests may be run with the maximum of ease and in the minimum of time.

A typical dc dynamometer control system is shown in Fig. 7, with amplifying generator control on the generator and dynamometer fields to control speed or



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torque. Extreme flexibility is provided by the system for motoring or absorbing with dynamometers.

Torque control of a dynamometer can be modified by auxiliary controls to simulate various conditions. For example, conditions of a car climbing a hill can be simulated by a speed boost or grade control which increases torque in proportion to speed. Wind resistance can also be simulated, but additional torque, proportional to the square of the speed, is required. This is achieved by using two tachometer generators belted to the dynamometer shaft.

Usefulness of the dynamometer as an engineering tool has increased greatly with the recent development of programming methods which allow automatic and controlled operation of a dynamometer through a complete test cycle. Two methods of dynamometer programming may be used: Cycling control, and feedback signal programming.

Cycling Control: Cycling control consists primarily of running an engine at two predetermined simultaneous conditions of speed and torque. Timers, relays, and/or servo systems are used to cycle dynamometer speed controls from speed 1 to speed 2 and engine throttle controls from torque 1 to torque 2. Servo systems (pneumatic or electronic positioning devices) may be elaborated upon to vary rate of speed and/or torque change. Still more elaborate stepping devices, such as switches or control potentiometers, can increase the number of conditions of speed and torque to produce a test cycle approaching an actual operating cycle. The cycling control method, however, is an open loop type of control with no feedback signals of speed and torque to assure duplication of desired test conditions.

Feedback Signal Programming: To close the loop of the control system and accurately reproduce required speed and torque programming under varying engine and dynamometer conditions, feedback speed and torque signals are necessary. These signals are compared to program signals. The error signal automatically adjusts both the dynamometer controls and engine throttle controls to produce the required program of speed and torque.

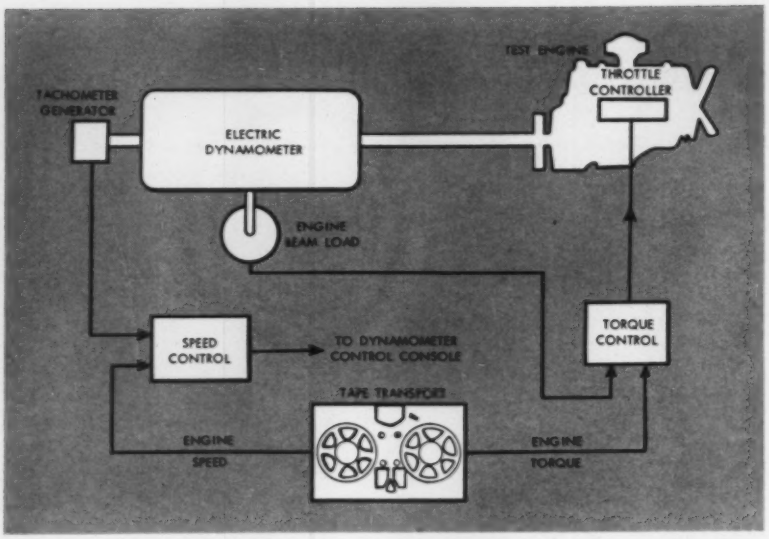


Fig. 8—Dynamometer usefulness increased by programming methods. Here, a dynamometer subjects an engine to speed and torque conditions which have been recorded previously on an instrumentation-type tape recorder under actual operating conditions.

Test runs, for example, are made on the road with engine speed and torque recorded simultaneously on an instrumentation-type tape recorder using strain gage torque and tachometer generator speed tranducers. The tape is then used to furnish signals, through suitable amplifiers, to program the dynamometer and engine controls, Fig. 8. Feedback signals are furnished by the dynamometer tachometer generator for speed and by the dynamometer torque-measuring system for torque. The strain-gage type torquemeter will supply more accurate torque signals during accelerations, since its output includes the inertia torque contributed by the weight of the rotating parts, such as the dynamometer armature.

To make the dynamometer program more complete, other variables, such as varying temperatures and pressures of engine oil, water, and transmission, can be tape recorded during a test. These variables can be controlled, along with speed and torque, with suitable pressure and temperature controllers and feedback transducers on the mediums involved.

Safety Interlocks: Interlocks refer to a system of sensing transducers, controllers, relays, and contacts used to protect both personnel and equipment from malfunctions and beyond-capacity conditions of operation. The unsafe condition is sensed by the transducer which causes the controller to actuate suitable controls to shut down the equipment and turn on identifying warning lights.

Interlocks supplied by the manufacturer protect dynamometer equipment against occurrences such as armature over-current and over-voltage, field loss, dynamometer and generator over-speed, and dynamometer reversing. Interlocks supplied by the user operate a master relay to stop the dynamometer when de-energized. This arrangement protects equipment being tested against such things as overheating and loss of pressure, engine ignition, and fuel supply failure. A "fail safe" design, which shuts down equipment when either electrically de-energized or if a transducer fails, is preferred and usually requires more relays and/or contacts.

From "A Discussion of Present Day Dynamometers: Their Application, Operation, and Control," presented in General Motors Engineering Journal, Vol. 4, No. 4, Oct.-Nov.-Dec., 1957.

(Advertisement)

A Review of the Phosphate Coatings

Specified for the Protection of Metal Surfaces

By HUGH GEHMAN, Assistant Manager, Product Development Dept., AMERICAN CHEMICAL PAINT COMPANY

Phosphate coatings are protective inorganic finishes that actually change the chemical nature of metal surfaces. The metal reacts with the applied phosphate solution to form a nonmetallic, crystalline coating which serves to:

- **Improve paint adhesion**
- **Provide protection against corrosion**
- **Increase lubricity of friction surfaces**
- **Facilitate mechanical deformation of metals**
- **Decorate—in many instances**

Satisfactory protection of steel, zinc and aluminum surfaces against corrosion, paint peeling and blistering, and hard wear requires precision methods of chemical conversion coating.

Types of Conversion Coatings

There are seven classes of chemical conversion coatings commonly specified and used throughout industry today. They are as follows:

Zinc-iron phosphate (ACP Granodine®). This is the heaviest type of coating (gray in color) used for prepaint treatments on steel, iron and zinc surfaces. The process requires five or six operations: cleaning; rinsing; rust removal, if necessary; coating; rinsing; and a second rinse. Coating weight ranges from 100 to 600 mg per sq. ft.

Medium or large volume production of automobile bodies, appliances, projectiles and cabinets can be handled effectively.

The coating solution improves paint adhesion by forming a crystalline deposit over the metal surface. This deposit is rough, as revealed microscopically, and so offers an ideal gripping surface for paint particles.

Manganese-iron phosphate (ACP Thermoil-Granodine®). This is a heavy black coating used on friction surfaces to prevent galling, scoring and seizing of parts. Typical metal parts treated are pistons, piston rings, gears, cylinder liners, camshafts, tappets and various small arms components.

Iron phosphate (ACP Duridine®). This is a comparatively new process that places a light coating on surfaces for improved paint adhesion. Since cleaning and coating occur in the same bath, it has only three to five stages.

The iron phosphate treatment is a spray process suited for medium to large volume, large or small work. Precleaning is normally unnecessary, an economy factor in its favor.

Products protected by this process are steel or iron fabricated units, such as cabinets, washing machines and refrigerators. Weight of coating is 50 to 100 mg per sq. ft.

Zinc phosphate (ACP Lithoform®). This is a crystalline coating produced on galvanized iron and other zinc surfaces—also cadmium—for improving paint adhesion. The purpose of the coating is to provide a paint-gripping surface and to prevent the reaction between acidic components of the paint and the zinc metal, with the formation of soaps and loss of paint adhesion.

This coating is applied in weights of 75 to 500 mg per sq. ft. There are no limitations on volume or production or on size of products treated. Zinc phosphate coating is used on zinc alloy die castings, zinc or cadmium plated sheet or components, hot dip galvanized stock, and Galvanneal.

Amorphous phosphate (ACP Alodine®). This is a relatively new protective coating for aluminum and aluminum alloys. It may be used in place of anodic deposition for improved paint adhesion and corrosion resistance.

This coating is practical for production in any volume. Coating weight is 100 to 600 mg per sq. ft. Products treated include helmets, belt buckles, aircraft and aircraft parts, bazookas and rocket motors, roofing and siding. Particularly good when aluminum is painted prior to forming.

Zinc-iron phosphate for oil absorption (ACP Permadine®). This is a relatively heavy coating adapted to the retention of rust-inhibiting drying or nondrying oils and waxes on ferrous metal surfaces. The coating is applied to a weight of 1000 to 4000 mg per sq. ft.

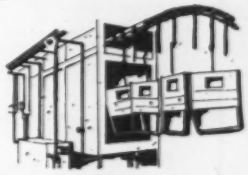
The process is satisfactory for large or small work in any volume—nuts, bolts, hardware, guns, tools, etc.

Zinc-iron phosphate for metal forming (ACP Granodraw®). This is a specialized coating used in conjunction with a suitable lubricant to facilitate the cold mechanical deformation of steel. The coating acts as an anchor for the lubricant throughout drawing, extrusion, and cold forming operations.

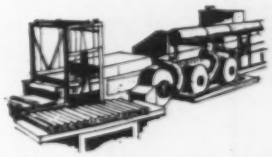
It is a successful treatment for products such as blanks and shells for cold forming, heavy stampings, impact extruded shapes, drawn wire and tube.

For more complete information about any one or all of these chemical conversion coatings, contact an ACP sales representative or write us at Ambler, Pa.

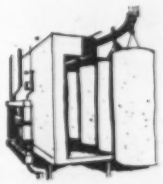
Typical Installations of Phosphate Coating Systems



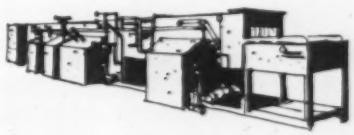
Customer: Truck manufacturer
Problem: Preparing cab parts for painting
Cycle: Phosphate wash; phosphate wash; rinse; chromic acid rinse; dry



Customer: Aluminum screen manufacturer
Problem: Final finish of aluminum shade screen
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry



Customer: Water heater manufacturer
Problem: Preparation of water heater shells for synthetic enameling
Cycle: Phosphate wash; rinse; chromic acid rinse; dry



Customer: Hardware manufacturer
Problem: Preparing hardware parts for painting
Cycle: Wash; rinse; phosphate coat; rinse; chromic acid rinse; dry

CHEMICALS ACP PROCESSES

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New Chemical Horizons for Industry and Agriculture

Circle 477 on Page 19

Factors affecting

Electronic Machine-Control Reliability

By HARRY L. PALMER
Manager, Engineering
Specialty Control Dept.
General Electric Co.
Waynesboro, Va.

RELIABILITY of equipment is normally expressed as the probability of equipment performing adequately for a specified period of time, although it may be expressed as the percentage of normal production time that equipment is maintained in an operating condition.

A number of factors affect reliability of an electronic machine-control. Among those considered most important are:

1. Electrical design.
2. Mechanical design.
3. Operating environment.

Electrical Design: Circuit tolerance, or factors of safety provided in signal and operating voltages, can have a considerable bearing on initial installation and necessity for readjustment of electronic equipment. This is considered separately from component tolerance. The electrical designer is definitely responsible for the reliability of the control because it is in his power to provide adequate tolerances in the equipment. This situation is sometimes magnified by the use of marginal components which do not permit adequate safety factors in the circuit because of possible overloading or exceeding operating ranges.

It is also the responsibility of the electrical circuit designer to use components far enough below their ratings to avoid component failures due to short life. Many of the components used in industrial electronic equipment must be borrowed from the communications industry and, in many cases, have published ratings in line with appreciably shorter life than can be tolerated in industrial equipment. The electrical designer must take these factors into consideration when selecting components to insure adequate life of the equipment.

Many components are manufactured under wide tolerance specifications. Therefore, the circuit design must be such as to accommodate these wide tolerances, or components must be selected to suitable tolerance limits. In addition to the deviation from rated values, many components change their characteristics appreciably with temperature or other operating conditions which must be accounted for in the original design.

Mechanical Design: From the maintenance point of view, accessibility of all components is essential. The design should permit removal of any component without completely dismantling the control. Most industrial users of electronic equipment recognize the fact that the layer type of construction employed in many radio chassis offer a severe handicap to the maintenance man.

Method of assembly also has a bearing on reliability. There is considerable disagreement on just what is the best type of construction. For example, some manufacturers and users feel that the only reliable electrical connection is a soldered joint, while others have found that the only connection which can be depended upon is one involving screw-type terminals with lock washers. There is also considerable disagreement on use of plug-in subassemblies. Some feel that the ability to sectionalize equipment and remove functional subassemblies for repair and replacement is essential to reliable equipment while experience of other individuals is such that they look with definite distrust on any unnecessary sliding or pressure contacts. There are those, too, who favor encapsulation of groups of components.

Both the mechanical designer and electrical designer must take into account effects of environmental conditions. If equipment is not given adequate protection from these adverse operating conditions, it will surely be unreliable. Many times it is exceedingly difficult for the mechanical designer to acquire information on operating conditions and, therefore, the manufacturer and user have a definite obligation to the designer to acquaint him with them.

Operating Environment: Dust and dirt are probably the most commonly encountered difficulties. Nonconducting particles theoretically do not cause difficulty with static equiment. However, they can have considerable effect on bearings and other moving parts of contactors and relays, as well as mechanical accessories. Dust and dirt combined with moisture offer a very serious leakage problem, especially in the case of high-impedance electronic circuits. It is possible to operate with much

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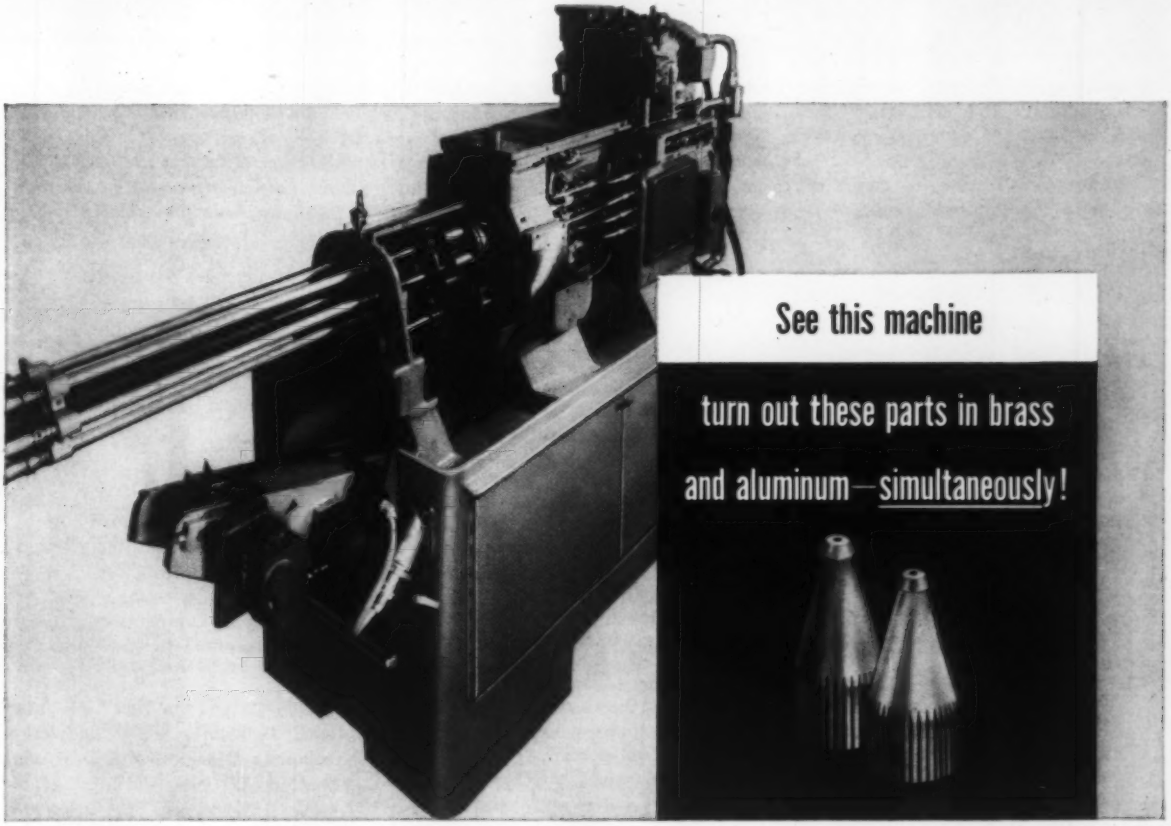

See screw machine parts produced in aluminum at less cost than steel or brass

When Alcoa and National Acme Company sponsored a machining demonstration in Cleveland last September, 700 design and production engineers and purchasing people saw aluminum and brass parts produced *simultaneously* on a six-spindle automatic screw machine—saw documented evidence that screw machine parts can be produced cheaper in aluminum than in brass or steel. Many expressed frank amazement at the cost comparisons shown.

Here is eye-opening machining news for all industry. Now *you* can see this demonstration, which Alcoa will sponsor in Chicago,* Boston, New York, Detroit, Los Angeles and other important centers.

If your function is design or production of products that use screw machine parts, you will find the Alcoa machining demonstration an enlightening experience. You will see how aluminum offers the ultimate in design freedom because it's so workable, so easy to machine—because it gives better finishes including anodized color. You will see the new color movie about Alcoa Screw Machine Stock, "The Four Amazing Alloys."

Send in the coupon for your invitation—and for a Design Calculator (slip-stick) for use with Alcoa® Aluminum Screw Machine Stock.

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Circle 478 on Page 19

closer spacings, under laboratory or clean conditions, than is normally possible in an industrial plant. It is the responsibility of the mechanical designer to protect his equipment and still meet the builder's or user's space requirements.

Temperature is often a cause of trouble in an electronic control if the control has not been designed for the temperature or temperature variations encountered. Mercury thyratrons have both high and low temperature limitations, which is why the trend has been away from mercury to other gases having a wider operating range. Tubes are not the only components which are affected by either high or low temperatures. With some components the life will be affected, while in others, characteristics will change which may call for readjustment.

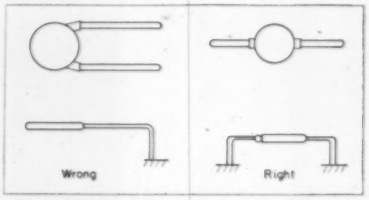
Shock and vibration are operating conditions which can be accounted for by the designer if he is advised as to the needs.

From a paper entitled "Reliability of Electronic Machine Controls," presented at the AIEE Machine Tool Conference in Milwaukee, Wis., November, 1957.

Effects of Vibration on Electronic Equipment

THE following observations are the results of a study to determine design criteria for electronic equipment subject to vibration:

1. Relays withstand vibration better when energized than when de-energized.
2. Vibration perpendicular to the shaft of a potentiometer is more apt to produce malfunction than other planes of vibration. Decreasing shaft mass or increasing shaft stiffness increases vibration resistance of the potentiometer.
3. Critical components should be located at the edge of the printed board and less critical components such as resistors and capacitors at the center.
4. Lead wire should be anchored so that there is no stress on solder points and terminals.
5. Wire should be looped around the terminal to eliminate the high stress on solder joints.
6. Wire should be anchored at intervals along its length if it extends a long distance between terminals.
7. Dimples are very effective in raising chassis panel resonant frequencies.
8. Wiring, allowed to surround critical components such as tubes and relays, will provide frictional damping.
9. Stress concentrations in chassis design should be avoided.
10. Insulated wire is more highly damped than noninsulated wire.
11. Capacitors should be mounted as shown to raise resonant frequency. Large displacements



associated with the low frequency of the cantilever design will result in fatigue failure of the leads.

From a paper entitled "An Analytical Technique of Electronics Equipment Design for Vibration," presented at the National Electronics Conference in Chicago, October, 1957, *by M. E. Gurtin, formerly with the Light Military Electronic Equipment Dept., General Electric Co., Utica, N. Y.*

Cellular Plastic Insulating Panels

INSULATION is available today in sandwich form which not only acts as a heat barrier but adds structural strength to units requiring insulation. Basically, the sandwich panel consists of an inner and outer skin material laminated to a plank of rigid cellular plastic insulation. Deep-freeze cabinets, for example, are formed by notching the panels with 90 degree V-slots and folding. By cementing the joints at these corners and adding front and rear panels, a cabinet is formed which is equivalent to the conventional type. The prefinished inner and outer skins require no additional treatment and serve as food compartment and outer shell respectively.

Advantages of sandwich construction are:

1. No roll-forming equipment or large presses are required.
2. No welding equipment is necessary for fabrication.
3. No auxiliary finishing equipment is needed.
4. All supports and inserts can be glued into the foam with adhesives.
5. Ordinary woodworking tools and equipment are used for construction.

Any cellular foam which has a thermal conductivity equivalent to glass fiber, which has low water vapor transmission rate and water absorption, and which can maintain acceptable thermal insulation over a long period of time is suitable for sandwich-type insulation.

As an example of the strength of one type of sandwich construction, a panel of 1 lb/cu ft density, 16 ft long by 2 ft wide and 3 in. thick covered with 0.032-in. aluminum skins showed a deflection of only 1 in. under a 150-lb load.

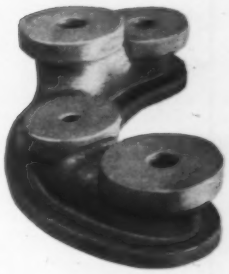
From a paper entitled "Cellular Plastics in Appliance Construction," presented to the Cellular Plastics Div. Conference of the Society of the Plastics Industry Inc. in New York, October, 1957, *by F. R. Marshall, Westinghouse Electric Corp., Columbus, Ohio.*

(Advertisement)

THE DODGE STEEL ladle
DS
BUSINESS MAGAZINE EDITION

PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

Designing steel castings for lower cost



Many times we have been asked, "What should designers and buyers know about steel castings?" If a single answer were possible, it would have to be that steel, like any other material, has its own characteristics. The design engineer must act from a sound knowledge of these characteristics, so that he may allow for them in the design of his casting.

It would be most helpful to the designer if he were constantly aware of the following four fundamental characteristics concerning steel as it cools from the molten condition to room temperatures:

- Low fluidity
- High shrinkage
- Low strength at solidifying temperature
- High cooling stresses

Let's discuss each:

LOW FLUIDITY

Liquid steel flows less easily than other common metals. Because of this, cast sections should not be designed so thin that lack of fluidity may cause losses from failure to reproduce the contours of the mold.

HIGH SHRINKAGE

The volumetric contraction that takes place when steel transforms from the liquid into the solid state is comparatively high. Therefore, sections should be so designed as to permit proper feeding from a supply of liquid steel. If this is not done, cavities will result in the casting.

LOW STRENGTH AT SOLIDIFYING TEMPERATURE

Steel, like most other metals, is neither strong nor ductile at temperatures just low enough to cause it to solidify. Hence careful attention must be given to design features from the standpoint of reducing possible stresses which might be caused by such factors as abrupt changes in section.

HIGH COOLING STRESSES

The designer must remember that a steel casting section solidifies from the outside toward the center. The rate of solidification is roughly the same regardless of section thickness. Thus, heavier sections take longer to solidify than lighter sections. By proper design of section changes, it is possible to minimize stresses.

Remember too, that steel castings, because of their cast-to-shape nature, can be readily and easily shaped to meet rigid design requirements.

Another phase of steel casting design will appear in the next Dodge advertisement. Meanwhile, we would be pleased to discuss your castings requirements with you, at the blueprint state, or earlier. Write today.

DODGE FINISHED PRODUCTS DIVISION

Many Dodge customers think of us as suppliers of one product only . . . quality steel castings. Today, however, a visitor to Dodge will find stacked piles of *aluminum swimming pool skimmers, telephone cable pliers, and finished machined parts* of all kinds on our shipping platforms . . . typical output of our Finished Products Division. Originally developed to rough machine DS Steel Castings, this important division of our organization has grown into a complete manufacturing plant. Here, facilities are available for producing products and components for a variety of applications, as well as general machine work in just about any metal or material. A brand new bulletin describing the facilities and services of this division is available. May we send you a free copy? There's no obligation, of course.

Circle 479 on Page 19

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Gears, Wheels, Couplings

Issued as a supplement to the main 128-page PIC catalog, pocket-size Catalog 13 provides dimensional data and specifications on 24 to 200 pitch gears, gear assemblies, pitch worm gears, coupling, and precision internal gears. 64 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 581 on Page 19

Sprockets & Chain

Simplified Electrolized and case hardened Flat-Veyor chain with high tensile strength is described on data sheet CD-103-A. It is offered in 3¼ to 7½-in. widths for maximum working load of 750 lb. Companion sprockets are also covered. 1 page. Browning Mfg. Co., Maysville, Ky. G

Circle 582 on Page 19

Metalworking Presses

Function of four column, single-action hydraulic presses in various forms of metalworking is depicted in Bulletin 6.17. Presses will perform high tonnage drawing and forming, die quench forming, stretch forming, deep drawing, steel and aluminum forging, heavy plate working, and straightening. 16 pages. Lake Erie Machinery Corp., 1002 Woodward Ave., Buffalo 17, N. Y. F

Circle 583 on Page 19

Seal Rings

Offered for interchangeable use with AN6290 O-ring sizes on AND-10056 fittings in the AND10050 boss, Wingseal synthetic rubber sealing ring is available in sizes from 2 through 32 for 1/8 to 2-in. tube fittings. Complete data are given in Catalog 5701. 12 pages. Parker-Hannifin Corp., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 584 on Page 19

Shaft Couplings

Bulletin F-10 lists general conditions where shafts and coupling should be considered in joining machinery. It outlines types of shafts and couplings available. Engineering data in Bulletin F-11 simplifies shaft selection and installation. 4 and 8 pages, respectively. H. S. Watson Co., 1316 67th St., Emeryville 8, Calif. L

Circle 585 on Page 19

Hydraulic Fluids

"Selection, Operation, and Maintenance of Hydraulic Fluids for Industrial Machinery" is title of Bulletin 1300SA. It describes the desirable and undesirable characteristics of petroleum base and fire resistant hydraulic fluids. Guidance is offered in selection of best fluid for a given job. Included are viscosity recommendations, rust prevention, and preventive maintenance. 24 pages. Vickers Inc., Box 302, Detroit 32, Mich. H

Circle 586 on Page 19

Voltmeter & Signal Amplifier

Model TBM true root-mean-square voltmeter for random-signal sources and the Model SND sum and difference amplifier are described and specified in two bulletins. 2 and 1 page, respectively. Flow Corp., 85 Mystic St., Arlington 74, Mass. B

Circle 587 on Page 19

Film Adhesives

Special Product Report on Plymaster V-2 and V-3 100 per cent reactive elastomer-phenolic film adhesives outlines generic advantages of these dry, solvent-free films. They are made in 4 and 11-mil thicknesses for flat-surface bonding of all metals and plastics. 10 pages. Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. J. D

Circle 588 on Page 19

Teflon Hose & Fittings

Details of the new Teflon 140 hose and industrial reusable fittings are contained in illustrated Bulletin T-140. Fittings withstand pressures to 3000 psi and temperature from —100 to 450° F. Details of assembly procedure are included. 4 pages. Titeflex, Inc., Hendee St., Springfield 4, Mass. B

Circle 589 on Page 19

Uses of Photocopying

How Verifax copying techniques can save money and increase efficiency in office and design departments is explained in illustrated booklet entitled, "Verifax Copying—Versatile Time-Saver for Busy Offices." Case histories are cited. 16 pages. Eastman Kodak Co., Business Photo Methods Div., Rochester 4, N. Y. F

Circle 590 on Page 19

Axial Flow Fans

Offered in ratings from 16 to 5000 cfm, Pesco axial flow fans are recomended for air supply and exhaust applications for intermittent or continuous duty. Data on these packaged fans for mounting directly in ducts are given in Bulletin 7503. 4 pages. Borg-Warner Corp., Pesco Products Div., 24700 N. Miles Rd., Bedford, Ohio. G

Circle 591 on Page 19

Copper Alloys

"Corrosion Resistance of Copper and Copper Alloys" is title of Reference Booklet B-36R. It reports the results of 31 years of continuous laboratory research and field study of the nature of corrosive attack on these metals. Included is tabulation of the relative corrosion resistance of these metals to 186 corroding agents. 32 pages. American Brass Co., Waterbury 20, Conn. B

Circle 592 on Page 19

Reversing Motors

Features of Inst-O-Verse instant-reversing electric motors which are available as single-phase, 1725 rpm, 115-v or 230-v, sleeve or ball bearing types in ratings through 1 hp are cited in Form P-86011. 4 pages. Franklin Electric Co., Bluffton, Ind. J

Circle 593 on Page 19

Controlled Air Cylinders

Design and application data on AllenAir Valve-in-Head cylinders in single and double solenoid types are given in Bulletin CY-1. Bleeder, hand valve, automatic reciprocating, and mechanical types are also described. 4 pages. A. K. Allen Co., 255 E. Second St., Mineola, N. Y. D

Circle 594 on Page 19

Control Valve

Described in data sheet is the Fig. 235-1 adjustable cam, lever-operated valve for accurate metering control of fuel oil in industrial oil burner installations. It will control and maintain a fixed ratio between two variables such as air and oil. 1 page. Atlas Valve Co., 280 South St., Newark 5, N. J. D

Circle 595 on Page 19

Plastic Laminate

Corrosion resistant Kel-F plastic laminate can be applied to any surface having almost any contour. Bulletin AD-152 outlines the properties of this material. Methods of application are explained, and typical uses are detailed. 4 pages. United States Gasket Co., Camden 1, N. J. F

Circle 596 on Page 19

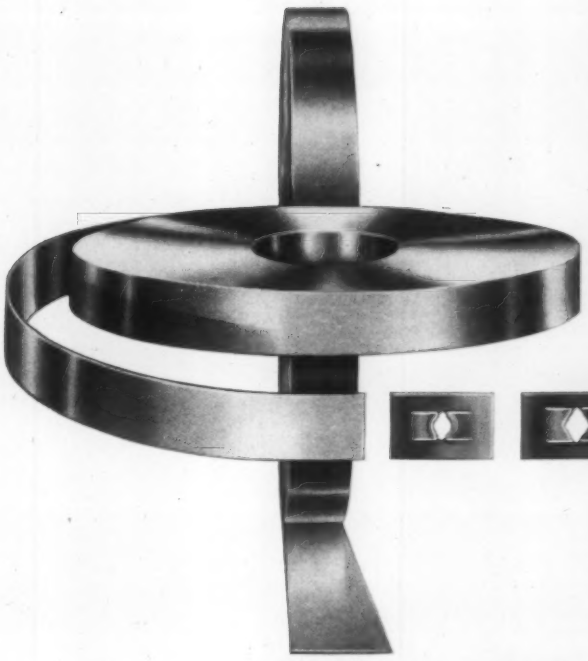
DC Amplifier

Engineering Bulletin 512-1 is descriptive of the Model 512 direct current amplifier which has an output of 0 to 35 v and 0 to 40 megacycles. Gain ranges from 0 to 1000 in ten steps. 2 pages. Allegheny Instrument Co., 1091 Wills Mountain, Cumberland, Md. C

Circle 597 on Page 19

Steel Tubing Weights

Simplified instructions for determining the weights of square and rectangular steel tubing are presented in illustrated booklet entitled, "Weight Tables—Rounded Steel Tubing." Weights are applicable to weld-



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Circle 480 on Page 19

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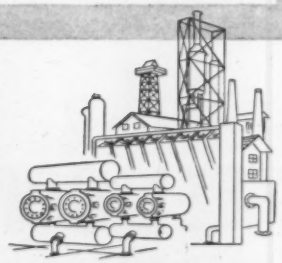
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Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 481 on Page 19

Helpful Literature

ed or seamless tubing. 16 pages. Revere Copper & Brass Inc., Rome Mfg. Co. Div., Box 111, Rome, N. Y. C

Circle 598 on Page 19

Exciter-Demodulator

Details of the new Model 200 and 200L exciter-demodulators which enable direct recording of differential transformer transducers are given in Bulletin 200. 2 pages. Daytronic Corp., 216 S. Main St., Dayton 2, Ohio. G

Circle 599 on Page 19

Humidity Test Chamber

A new humidity test chamber simulates environmental conditions throughout the temperature range of 0 to 200° F and 5 to 98 per cent relative humidity. Controls include a 12-in. wet and dry bulb recorder, controller, and programmer. Details are given in illustrated bulletin. 4 pages. Environmental Equipment Co., 369 Linden St., Brooklyn 27, N. Y. D

Circle 600 on Page 19

Capacitors

Specifications of a full line of polystyrene, polyethylene, Teflon and Mylar dielectric capacitors and high voltage packaged power supplies are cataloged in illustrated bulletin. 6 pages. Film Capacitors, Inc., 3400 Park Ave., New York 56, N. Y. D

Circle 601 on Page 19

Add-Subtract Counter

Actuated by add and subtract pulses, the HZ200 Series counter described in Bulletin 740 is designed for count control between two limits. It is suited for parking lots, conveyor systems, and other applications. 2 pages. Eagle Signal Corp., Moline, Ill. I

Circle 602 on Page 19

Positive Displacement Pump

Model R Series automatic reversing pumps are subject of Catalog Section 105. These rotary, internal geared pumps are used in lubrication, coolant, hydraulic power, and circulating services. Pressures range to 400 psi and capacities to 200 gpm. 12 pages. Tuthill Pump Co., 939 E. 95th St., Chicago 19, Ill. J

Circle 603 on Page 19

Drive Unit

Capable of transmitting rotary, linear, or angular motion accurately, the new Harmonic Drive principle is explained in illustrated file folder. System utilizes a controlled deflection wave for positive transmission of power and information. 4 pages. United Shoe Machinery Corp., Research Div., 140 Federal St., Boston, Mass. B

Circle 604 on Page 19

Machining Thermoplastics

Recommended procedures for machining and finishing thermoplastic sheets, rods, and tubes are presented in illustrated bulletin. Discussed are such operations as sawing, routing, punching, drilling, turning, and polishing. Tool design, feed, speed, and coolants are covered. 8 pages. Cadil-

Helpful Literature

lac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich. H

Circle 605 on Page 19

Adjustable Speed Drive

Bulletin 2000 is descriptive of the Select-A-Spede adjustable speed drive. It is available in ratings from 5 to 200 hp. This variable-voltage direct current drive uses alternating current as a power source. 12 pages. Louis Allis Co., 427 E. Stewart St., Milwaukee 1, Wis. K

Circle 606 on Page 19

Cooling Effect Detection

When cooling critical equipment by air, a cooling effect control system reduces power needed to provide adequate cooling by programming the air temperature or weight flow to maintain constant cooling effect in the supply air. Systems are described in Bulletin F-8512. 4 pages. Barber-Colman Co., Aircraft Controls Div., Rockford, Ill. K

Circle 607 on Page 19

Flow & Rate Limiters

Flow and rate limiters, applications of which are shown in file folder, feature accuracy approaching ±1 per cent. Line includes sizes from 0.5 to 11 gpm. 4 pages. Conair Inc., 731 W. Wilson, Glendale 3, Calif. L

Circle 608 on Page 19

Flow Control Valves

Diaphragm type, nonlubricated constant flow control valve serves wherever pressure in a fluid line fluctuates. Working pressure is 5000 psi. Flow rate is 45 gpm. Pocket-size folder explains design, construction and performance characteristics. Kobe, Inc., Huntington Park, Calif. L

Circle 609 on Page 19

Gas Thermostat

Detailed diagrams and drawings on the Model DG high capacity gas thermostat are contained in Bulletin RT-813. Capacity of ¾-in. size control is 145,600 Btu for manufactured gas, 215,500 for natural gas and 455,800 Btu for LP-gas. 4 pages. Robertshaw-Fulton Controls Co., 110 E. Otterman St., Greensburg, Pa. F

Circle 610 on Page 19

Rotary Face Seals

Brief description of rotary face seals is given in Bulletin 301. Seals are designed for difficult sealing problems on high speed rotating shafts. 1 page. Skinner Seal Co., 3001 Sutter St., Santa Ana, Calif. L

Circle 611 on Page 19

Supervisory Control

The what, why, and wherefors of supervisory control equipment are covered in Bulletin GEA-6603. It describes functions ranging from opening and closing switches and valves, to adjustments of speed, voltage, or load. 16 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 612 on Page 19

Solenoid Valves

Series of five data and specifications sheets provide information on

NOW HIGH POWER 60 AND 400 CPS TRANSI-MAGS®

STANDARD LINE OF FAST RESPONSE

TRANSISTOR MAGNETIC AMPLIFIER

FOR SERVO MOTOR CONTROL

For driving AC servo motors in industrial and military servo systems which require hi-power, fast response and (static) high reliability.

A COMPLETE SERVO AMPLIFIER DRIVE SYSTEM IN A SINGLE PACKAGE
TEMPERATURE STABILIZED
FAST RESPONSE
HIGH GAIN
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SMALL STANDBY POWER
RUGGED
HIGH RELIABILITY
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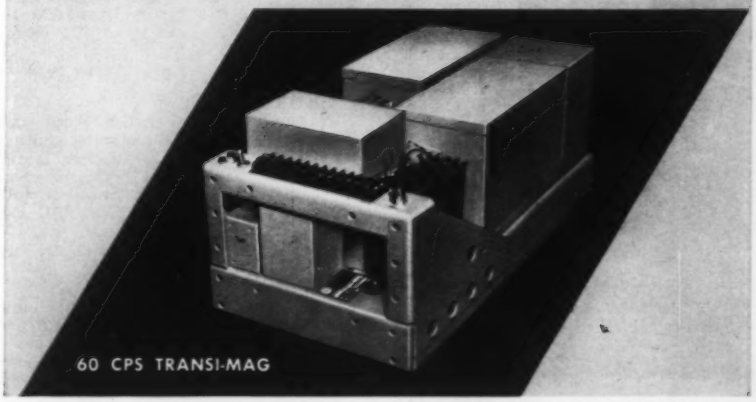
SERVO MOTOR COMPATIBILITY



60 CPS TRANSI-MAG

60 CPS PERFORMANCE SPECIFICATIONS

For complete 60 CPS and 400 CPS Transi-mag specs Write For Bulletin S-890.

MODEL A.C. INPUT D.C. INPUT	TMA-1501 TMA-1511	TMA-1551 TMA-1561	TMA-1571 TMA-1581	TMA-1601 TMA-1611	TMA-1701 TMA-1711	TMA-1801 TMA-1811	TMA-1901 TMA-1911
MAX. POWER OUTPUT WATTS	50	100	120	375	650	1900	2800
TYPICAL SERVO MOTOR LOAD	Diehl FPF 49-9	Diehl FPF 49-12-1	Diehl FPF 66-11-1	Diehl FPF 85-18-1	Diehl ZP 105-2212-1	Diehl ZP 143-2247-1	Diehl ZP 162-2207-1
SENSITIVITY	A.C. Input — 0.3 volts A.C. for full power output D.C. Input — 0.15 volts D.C. for full power output						
RESPONSE	.05 seconds						
AMBIENT TEMPERATURE	− 55°C. to + 71°C						

MAGNETIC AMPLIFIERS INC.

632 TINTON AVENUE • NEW YORK 55, N. Y. • CYPRESS 2-6610

West Coast Division

136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

Circle 482 on Page 19

The reliability of Statham transducers is demonstrated by an experience reported by Chance Vought:

Two Statham pressure transducers which had not been calibrated for six years were recently calibrated with a resulting curve that checked within 2% of the last calibration.

IF YOU NEED

Linear Accelerometers
Angular Accelerometers
Gage Pressure Transducers
Absolute Pressure Transducers
Differential Pressure Transducers

in your instrumentation programs, please outline your requirements so we may submit specific recommendations.

WHEN THE NEED IS TO KNOW... FOR SURE SPECIFY STATHAM

Statham
INSTRUMENTS, INC.
LOS ANGELES 64

Circle 483 on Page 19

Helpful Literature

Models 291, 271, 272, 273, and 274 solenoid valves for hot gas and water applications. Working pressures range up to 400 psi. 2 pages each. Controls Co. of America, 2450 N. 32nd St., Milwaukee 45, Wis. K

Circle 613 on Page 19

Micro-Microammeter

Suggested uses and applications, as well as specifications and performance of Model 565A Electrometer are outlined in Bulletin 3008-7. Instrument measures low currents in ion chambers and high impedance networks. 1 page. Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio. F

Circle 614 on Page 19

Thermostats

Design data for adjustable and nonadjustable NorStat Type A thermostats are given in Bulletin A-1. This thermostat is suitable for home appliances, vending machines, and production machinery. 1 page. Norwalk Thermostat Co., Norwalk, Ohio. G

Circle 615 on Page 19

Hydraulic Motors

Specification Chart G-115 provides an easy method of selecting proper size hydraulic motor for a given application. Four models covered have torque capacities from 0 to 600 lb-in. 1 page. Gerotor May Corp., Owings Mills, Md. C

Circle 616 on Page 19

Transfer Valve

Fast, smooth transfer from one strainer or heat exchanger to another is provided by Type 45 duplex transfer valve. This valve is described as to design and performance in bulletin. A. W. Cash Co., Box 551, Decatur, Ill. I

Circle 617 on Page 19

Heat Exchangers

Performance improvements and new design features of expanded line of Type BCF heat exchangers are emphasized in Bulletin 1.1K6. Specifications cover 46 sizes in one, two, and four-pass designs. Modifications are also considered. 8 pages. American-Standard, Ross Heat Exchanger Div., Buffalo 5, N. Y. F

Circle 618 on Page 19

Phase Meters & Delay Lines

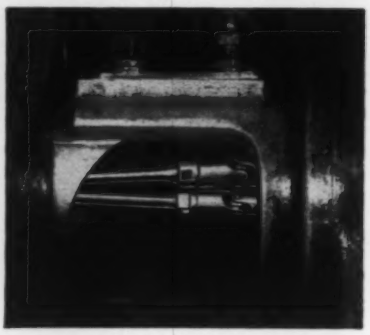
Bulletin on "Phase Meters, Delay Lines, and Counters" briefly covers features, specifications, and prices on 15 separate items. It is supplemented with data sheets on the Type 209 standard frequency signal generator and the Type 208 precision phase shifter. 4 pages. Advance Electronics Lab., Inc., 249-259 Terhune Ave., Passaic, N. J. D

Circle 619 on Page 19

Speed Control Drives

The elements of adjustable-voltage direct-current drives are incorporated in one-package speed control drives described in Bulletin 20,000. It explains basic circuit and the modifications available including speed regulation, constant-potential dc supply, dynamic braking, and acceleration

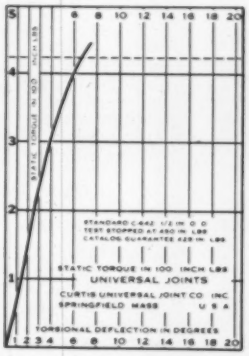
Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

Torque Curve ½" Curtis Universal Joint


STATIC TORQUE IN 100 INCH LBS
UNIVERSAL JOINTS
CURTIS UNIVERSAL JOINT CO. INC
SPRINGFIELD MASS U.S.A.
TORSIONAL DEFLECTION IN DEGREES

This is only one of many problems solved by Curtis Joints — size for size the strongest universal joints designed for industry. Selected materials, precision engineering, and over 30 years' experience manufacturing universal joints make them that way.

14 SIZES ALWAYS IN STOCK — 3/8" to 4" O.D. (6" joints on special order)

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UNIVERSAL JOINT CO., INC.
5 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 484 on Page 19

Helpful Literature

control. 8 pages. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio. F

Circle 620 on Page 19

Mechanical Tubing

Tolerance chart TDC-115 D tabulates permissible variations in diameter and wall thickness of round seamless carbon and alloy steel mechanical tubing. Both cold-drawn and hot-finished tubing are covered. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. C

Circle 621 on Page 19

Accelerometers

Photos, specifications, and descriptive matter on line of vacuum tube and transistorized accelerometers are contained in Data File 410. These servo accelerometers measure linear acceleration with precision. 4 pages. Donner Scientific Co., Concord, Calif. M

Circle 622 on Page 19

Nuclear & Specialty Metals

Melting, fabricating, testing, and quality control facilities of company's nuclear and specialty metals plant are described in bulletin. Zirconium, titanium, hafnium, niobium, tantalum, and thorium are among metals worked. 5 pages. D. E. Makepeace Co., Pine & Dunham Sts., Attleboro, Mass. B

Circle 623 on Page 19

Cable Assemblies

Ropeology Bulletin 57126 details prefabricated wire rope assemblies for original equipment. Offered with various fittings attached, they eliminate need for hand splicing, socketing, and bulky attachments. Several installations are shown. 4 pages. Macwhyte Co., Kenosha, Wis. K

Circle 624 on Page 19

Bearing Metal

Tests which demonstrate that Bearium metal bearings function efficiently under difficult conditions are described in color-illustrated folder. Metal is available in rough cast bars, ingot metal, centerless ground rods, castings, and machined parts. 4 pages. Bearium Metals Corp., 190 Mill St., Rochester 14, N. Y. F

Circle 625 on Page 19

Dynel Fiber

"The Story of Dynel" is the title of a booklet which details how the fiber is made, its properties, use, and care in diverse applications. 16 pages. Union Carbide Corp., 100 E. 42nd St., New York 17, N. Y. C

Circle 626 on Page 19

Synchronous Motor

Technical, operational, and design data on Series 117 permanent magnet synchronous motor are given in illustrated Bulletin PB-117. Specifications of five versions with torque ratings to 60 oz-in. are included. 2 pages. Cramer Controls Corp., Centerbrook, Conn. B

Circle 627 on Page 19

Vacuum Pumps

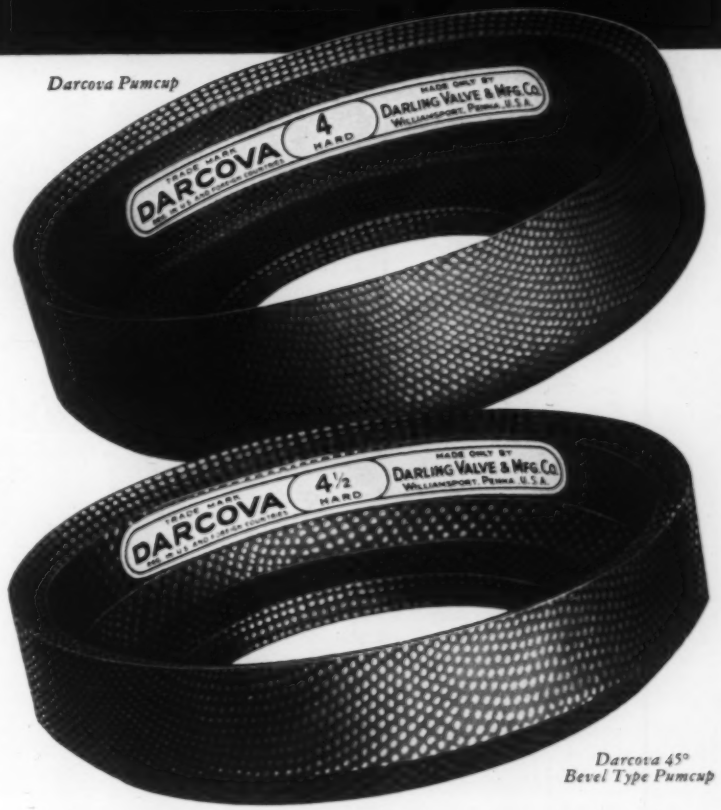
Outline drawings, tables, and large scale speed curves which present

DARCOVA PUMCUPS

now available with

100% NYLON COMPOSITION

for HYDRAULIC CONTROLS, AIR CYLINDERS, RECIPROCATING PUMPS



Darcova Pumcup

Darcova 45° Bevel Type Pumcup

DARLING Pumcups—long noted for unequalled efficiency and life in all kinds of cylinders—are now greatly exceeding their own performance records! The new 100% Nylon Composition, available *only* in Darcova Pumcups, does it!

Nylon Pumcups are made in sizes, types and textures exactly right for your particular equipment—ready *now* to give you unprecedented piston packing performance!

Write for helpful data Bulletin No. 5503.

DARLING VALVE & MANUFACTURING CO.

Williamsport 30, Pa.

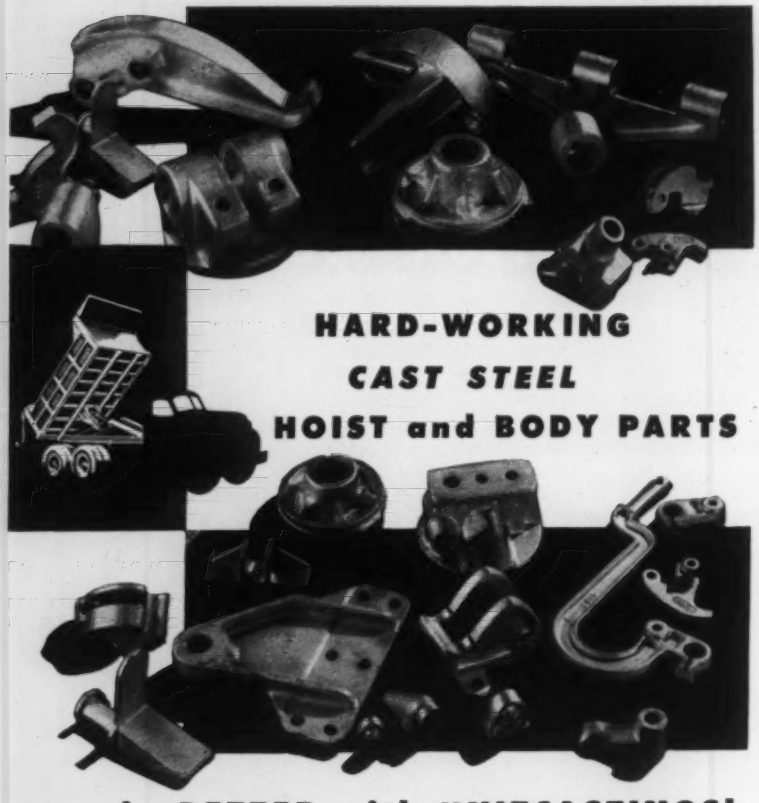
DARCOVA

THE ORIGINAL COMPOSITION CUP

TRADE MARK

PUMCUPS

Circle 485 on Page 19



...made BETTER with UNITCASTINGS!

When heavy-duty truck equipment is subjected to terrific poundings, extremely heavy loads, shocks, and stresses—its durability, ruggedness, and ability to "take it" depends on the quality of the components.

Steel castings are used for many of the "wear" parts in a major manufacturer's line of hoists and bodies because they "stand up" on the job . . . assure the required strength, resistance to wear and corrosion . . . offer good weldability and minimum weight.

"Foundry Engineered" Unitcastings meet the dimensional accuracy, internal soundness, good surface appearance and other requirements specified by the customer. In addition, Unitcast's modern steel casting methods and facilities make possible the *consistent uniformity* that means a *lower end cost!*

Let Unitcast's engineers show you how steel castings will serve you better! Write today for complete information.

UNITCAST CORPORATION, Toledo 9, Ohio

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Unitcast

SPECIFICATION STEEL CASTINGS

Helpful Literature

physical and operating specifications for mercury and oil high vacuum diffusion and booster diffusion pumps are found in illustrated bulletin. Speeds range from 10 to 11,000 cfm. Selection data are included. 12 pages. NRC Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass. B

Circle 628 on Page 19

Casting Plastic

Mixing proportions, working time, cure schedule, and typical physical properties of No. 11b unlimited thickness black casting plastic are given in illustrated data sheet. Prices are also given. 1 page. Furane Plastics Inc., 4516 Brazil St., Los Angeles 39, Calif. L

Circle 629 on Page 19

Way Protector

Illustrated Bulletin GW-100 describes a way protector that opens to 90 ft on both sides of a tool column and closes to a minimum of 24 in. Any width and/or length can be supplied. Neoprene-base materials are used. 4 pages. A & A Mfg. Co., 712 S. 12th St., Milwaukee 4, Wis. K

Circle 630 on Page 19

Pressure Reducing Valve

Dead end shut-off on all fluid services is provided by the OPW-Jordan pressure reducing valve. Its features, method of operation, capacity charts, control ranges, and specifications are contained in illustrated Bulletin J-160. 6 pages. OPW Corp., Jordan Industrial Sales Div., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 631 on Page 19

Silicon Transistors

Three silicon transistors which meet MIL-T-19500A format for life, environmental, electrical, and mechanical tests are covered in three technical folders. Hermetically sealed units are made by diffusion. Specifications are given. 4 pages each. Transitron Electronic Corp., Wakefield, Mass. B

Circle 632 on Page 19

Heaters & Heating Elements

Adaptatherm process for making electric heaters and heating elements is subject of illustrated folder "Direct Heat Transmission." An insulated resistance wire, formed to give the desired heat distribution pattern, is made an integral part of a casting of heat conducting material. 4 pages. H. W. Tuttle & Co., Adrian, Mich. H

Circle 633 on Page 19

Solenoids

Illustrations, dimensional drawings, and force characteristics of alternating and direct current industrial solenoids are found in illustrated Catalog 572. Oil immersed model is included. Specifications and ratings are given. Detroit Coil Co., 2435 Hilton Rd., Ferndale 20, Mich. H

Circle 634 on Page 19

Plastic Laminates

Looseleaf catalog describes Nelco thermosetting laminated plastic sheets for printed circuit and similar uses. It includes a materials list for

Helpful Literature

identification of each product by NEMA grade, resin and base, and characteristics. Technical data and prices are also included, along with application data. 15 pages. New England Laminates Co., 481 Canal St., Stamford, Conn. B

Circle 635 on Page 19

Fasteners, Rivets, & Tools

Huckbolt fasteners, blind rivets, and driving tools are described, and their features and specifications given in illustrated Catalog 8-415. Typical applications are shown. Fasteners feature high shear, tension, and fatigue strength, are water and gas tight, and eliminate vibration loosening. 12 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 636 on Page 19

Power Supply

Printed circuit, wide range Model 300-B power supply, the B-Nobatron, is subject of data sheet. It has a regulated output of 0 to 300 v dc and unregulated filament outputs of 6.3 or 12.6 v ac. Electrical and mechanical specifications are given. 2 pages. Sorensen & Co., Richards Ave., South Norwalk, Conn. B

Circle 637 on Page 19

Filters & Strainers

Filters and strainers for fluids and gases are described and their specifications, performance characteristics, and application data presented in General Catalog 58-100. Units covered fulfill a wide variety of industrial requirements in various industries. Cuno Engineering Co., S. Vine St., Meriden, Conn. B

Circle 638 on Page 19

Worm Gearing

Line of standard worm gearing, supplied in individually matched sets and providing high load carrying capacities on small center distances, is detailed in illustrated Bulletin 700-C. Single or double extended shaft worms and various gear types are available. Specifications and ratings are given. 16 pages. Michigan Tool Co., Cone-Drive Gears Div., 7171 E. McNichols Rd., Detroit 12, Mich. H

Circle 639 on Page 19

High Vacuum Valve

Choice of flange dimensions and thin design are features of a 6-in. VG Series high vacuum valve. Design and performance data and dimensional drawings are included on Data Sheet VG-3. 2 pages. Vacuum Research Co., 420 Market St., San Francisco 11, Calif. M

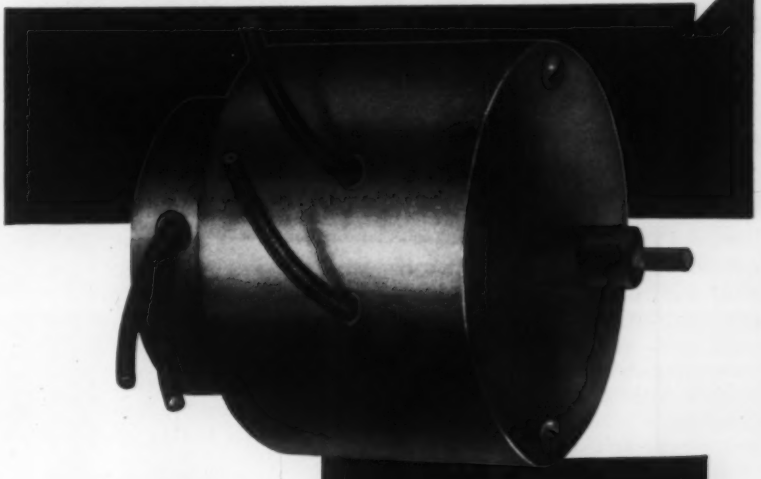
Circle 640 on Page 19

Plastic Shim Stock

Wil-Pak line of plastic gasket and shim stock, described in illustrated Bulletin 570, is furnished in six basic gages. Each thickness is identified by color and gage number. Material is impervious to oil and water, is dimensionally stable, and withstands 400° F. 4 pages. Chicago-Wilcox Mfg. Co., 7701 S. Avalon Ave., Chicago 19, Ill. J

Circle 641 on Page 19

HIGH TORQUE REVERSIBILITY

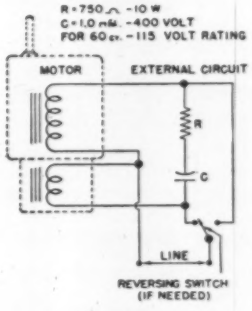


SERIES 830
HIGH TORQUE
REVERSIBLE
SYNCHRONOUS MOTOR

WIRING DIAGRAM

Designed to operate on 115 v. 60 cycles. Supplied with 6" leads. Guaranteed starting torque 80 inch ounces. External phase shifting circuit is required.

NOTE: If UL approval required—specify Bristol Series 530 motor developing 40 inch ounces.



Another exclusive Bristol Motor designed to answer your specialized needs! Measuring 2" x 2" x 2" over-all, the Bristol Series 830 develops exceptional high starting and synchronous torque – three times higher than most competitive motors. Positive reversibility, wide speed ranges, and low cost give this motor unusual versatility.

BRISTOL MOTORS

CIRCLE B BRISTOL

DIVISION of VOCALINE COMPANY OF AMERICA, INC.
107 COULTER ST. • OLD SAYBROOK, CONN.

WHEN SECONDS COME FIRST — SEE BRISTOL FIRST!

Circle 487 on Page 19

New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Coupling

accommodates radial, axial, and angular misalignment

Designed for precision coupling requirements in servo and instrument applications, Maxflex miniature coupling accommodates radial, axial, and angular misalignment in connecting shafts, motors, and components without backlash or error. Coupling eliminates tight location tolerances, and utilizes universal joints with no springs, pivots, or point contacts. Radial error to ±1/16 in., axial error to ±1/16 in., and angular error to ±15 deg are accommodated in a ¼-in. diam,

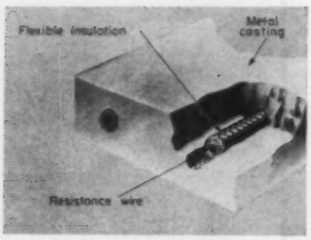
1⅛ in. long coupling. Unit operates from −65 to 300 F with no preferred position or whip action. Made of stainless steel combined with fluorocarbon plastic, coupling is available in ¼-in. male, ⅛ and 3/16-in. female sizes. **Parametrics,** P. O. Box 629, Costa Mesa, Calif. L

Circle 642 on Page 19

Electrical Heating Element

has braided glass fiber insulation

Insulated resistance wire, designated Adaptatherm, can be formed to any shape and cast into an aluminum mold for use in household appliances, heaters, and many other applications where heat from electricity is required. Resistance wire, with braided glass fiber insulation, is embedded in the casting in any pattern to achieve desired heat distribution. Moistureproof terminals are sealed in glass. Element provides low wire skin temperature, high surface temperature at the surface of the casting, and



increased wattage output. Element has low current leakage. **H. W. Tuttle & Co.,** Adrian, Mich. H

Circle 643 on Page 19

Stainless Tubing

is seamless, mandrel-drawn type

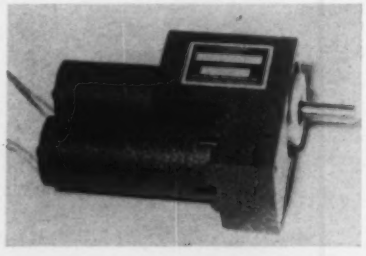
Lustraloy seamless stainless tubing is mandrel drawn in sizes from ⅜ to 1½ in. OD and 0.020 to 0.109 in. wall thickness. Smooth, mirrorlike interior makes the tubing applicable for heat exchangers, condensers, chemical apparatus, paper mills, aircraft hydraulic lines, and equipment for the atomic energy industry. Interior also resists clinging of solid particles, making tubing useful where a high degree of sanitation is required. **Summerhill Stainless Tube Div.,** Columbia Steel & Shafting Co., Carnegie, Pa. G

Circle 644 on Page 19

Miniature Differentials

provide smooth speed variation

New differentials are custom-built



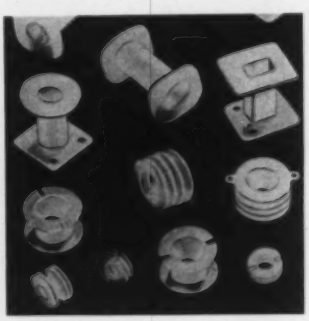
units containing two ac or dc motors and a precision gearing unit. Speed range is from 10 to 100 rpm in either direction. Torques to 2500 oz-in. are possible, with smooth changes through zero at full torque. Applications are in antenna drives, tracking devices, or digital-to-analog mechanisms. Package size varies with motors used. **Globe Industries Inc.,** 1784 Stanley Ave., Dayton 4, Ohio. G

Circle 645 on Page 19

Custom-Molded Bobbins

of any thermoplastic material

Small, precision custom-molded bobbins are available in nylon and other thermoplastic materials. Parts have a maximum length of



1¼ in. and maximum weight of ⅛ oz. Minimum wall thickness is 0.008 in. **Pee-Wee Molding Corp.,** Dept. 57A, 1720 Atlantic Ave., Brooklyn 13, N. Y. D

Circle 646 on Page 19

Subminiature Valves

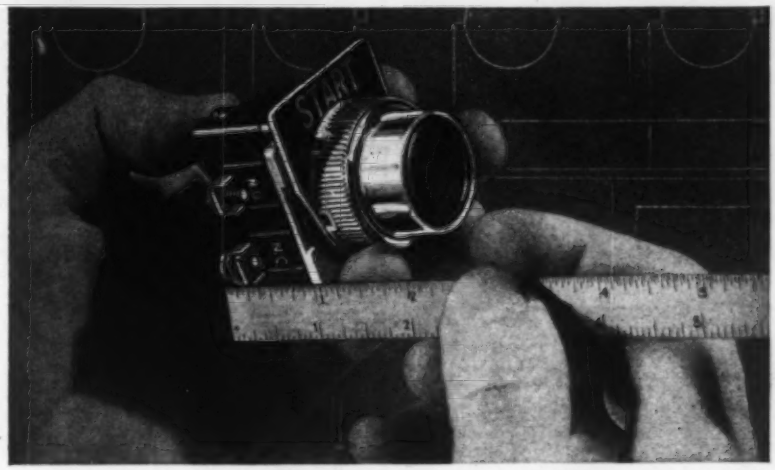
for pressures to 6000 psi and temperatures to 1000 F

Stainless-steel, two-way restrictor valves are miniature units for precise metering of gas or liquid flow. Designed for use in advanced aircraft and missile pressure systems, the valves are lightweight; ¼-in.

The Panelbuilder

85 YEARS OF SERVICE — CUTLER-HAMMER — MOTOR CONTROL — C-H

News for and about Panelbuilders



Space Saving Heavy Duty Oil-Tight Control Units Provide Greater Circuit Flexibility

To meet the demand for smaller, more flexible heavy duty oil-tight pushbuttons, indicating lights and selector switches, Cutler-Hammer developed the 10250T family of control units. These units, adaptable for either one-hole mounting or base-mounting, offer amazing opportunities for simplified compact control panel design.

Back-of-Panel Depth—1 3/32"

Cutler-Hammer's pushbutton units are available as either flush button, extended button or mushroom head operators. When one-hole-mounted, a double pole pushbutton unit extends only 1 1/32" behind the panel. The double pole contact blocks are available in any combination of normally open and normally closed contact. Each circuit is mechanically and electrically isolated from the other. For additional circuits, contact blocks can be quickly tandem mounted. No special attachments required. Operators come in six distinctive colors.

Indicating Lights Include PresTest

Cutler-Hammer 10250T oil-tight indicating lights, either resistor type or transformer type, have 180 degree non-blinding lenses. These unusually compact lights are available in six brilliant colors, with either unbreakable plastic or heavy glass lens. PresTest, the famous self-testing indicating light, permits instant checking for faulty bulbs without dismantling the unit. Merely by pressing on the PresTest lens, the bulb is disconnected from the normal circuit and checked on a separate test circuit.

Roto-Push—The One-Button Control Station

Cutler-Hammer's Roto-Push is a single unit that combines the functions of the pushbutton and selector switch. Available in either two or three position types, the guard ring rotates to select the desired function while the push-button actuates the circuit. Roto-Push offers practically unlimited circuit combinations and often it will replace two or three units. Cutler-Hammer's 10250T family also includes a complete line of two and three position selector switches in a variety of operators.

C-H Master Design

For complete information of Cutler-Hammer's 10250T family of control units write on your company letterhead for C-H Master Design, Pub. EL-178.

NEW HIGHER NEMA RATINGS FOR SIZE 0 AND SIZE 1 STARTERS AND CONTACTORS

NEMA recently approved increased horsepower and ampere ratings for NEMA O and NEMA 1 sizes of A-c across-the-line starters and contactors. This is a new industry standard to allow savings in space and cost in the majority of control applications. The following NEMA ratings are now in effect:

NEMA AMPERE RATINGS

A-c Magnetic Contactors

		Old	New
Size 0	open	15 amps	20 amps
	enclosed	13 amps	18 amps
Size 1	open	25 amps	30 amps
	enclosed	22 amps	27 amps

A-c Magnetic Starters

Size 0	open & enclosed	15 amps	18 amps
Size 1	open & enclosed	25 amps	27 amps

NEMA HORSEPOWER RATINGS

A-c Magnetic Contactors & Starters

Single Phase

		Old	New
Size 0	115 volts	1 Hp	1 Hp
	230 volts	1½ Hp	2 Hp
Size 1	115 volts	1½ Hp	2 Hp
	230 volts	3 Hp	3 Hp

Polyphase

Size 0	110 volts	1½ Hp	2 Hp
	208/220 volts	2 Hp	3 Hp
	380, 440, 550 volts	3 Hp	5 Hp
Size 1	110 volts	3 Hp	3 Hp
	208/220 volts	5 Hp	7½ Hp
	380, 440, 550 volts	7½ Hp	10 Hp

NOTE: NEMA Ratings have not been changed for special duty, plugging, inching, jogging, etc., or for tungsten lamp loads.

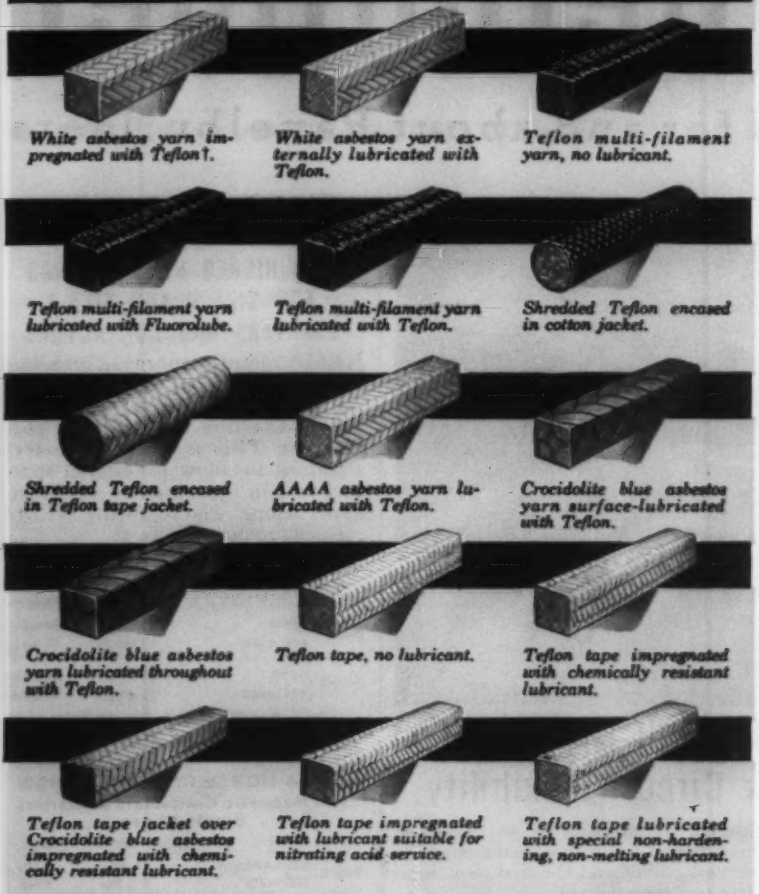
All starters and contactors in the Cutler-Hammer line of Three-Star Motor Control have been rerated to these new NEMA standards. Your nearby Authorized Cutler-Hammer Distributor *now* offers them from stock for non-reversing, reversing, and multi-speed requirements. Revised Cutler-Hammer catalog sheets showing all forms of control units with the new NEMA ratings will be supplied on request.

PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 70 page reference guide is specifically edited to assist design engineers and control panel builders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information and a maintained price list. Address your request for a personal copy on your company letterhead. CUTLER-HAMMER Inc., 1310 St. Paul Ave., Milwaukee 1, Wisconsin.

Circle 488 on Page 19

15 SPECIFIC PACKINGS FOR ALL CORROSIVE SERVICES



White asbestos yarn impregnated with Teflon†.

White asbestos yarn externally lubricated with Teflon.

Teflon multi-filament yarn, no lubricant.

Teflon multi-filament yarn lubricated with Fluorolube.

Teflon multi-filament yarn lubricated with Teflon.

Shredded Teflon encased in cotton jacket.

Shredded Teflon encased in Teflon tape jacket.

AAAA asbestos yarn lubricated with Teflon.

Crocidolite blue asbestos yarn surface-lubricated with Teflon.

Crocidolite blue asbestos yarn lubricated throughout with Teflon.

Teflon tape, no lubricant.

Teflon tape impregnated with chemically resistant lubricant.

Teflon tape jacket over Crocidolite blue asbestos impregnated with chemically resistant lubricant.

Teflon tape impregnated with lubricant suitable for nitrating acid service.

Teflon tape lubricated with special non-hardening, non-melting lubricant.

John Crane CHEMLON *BRAIDED PACKINGS

Specific service conditions are always best handled with a packing designed for the purpose. This is especially true when it comes to hard-to-handle liquids in pumps, valves, agitators, mixers, plating equipment and similar applications.

For this reason John Crane has developed 15 individual field-proved types of Chemlon Braided Packings. Within this line there is a type and style that will meet any combination of service conditions and requirements.

1. All known industrial acids, alkalis or solvents.
2. Temperatures from −120°F to +600°F.
3. High or low shaft speeds, also valve stems.
4. Longer packing life due to lower coefficient of friction and non-raveling construction.

Send in your service condition and we will recommend a Chemlon Braided Packing best suited to your application. Request Bulletin P-325.

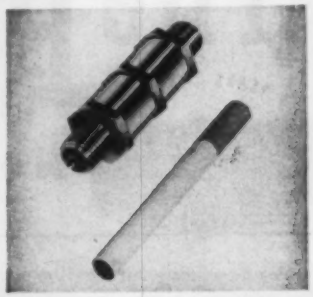
Crane Packing Co., 6425 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

†T. M. for DuPont Teflon **T. M. for the Best in DuPont Teflon*

John Crane MECHANICAL PACKINGS SHAFT SEALS TEFLON PRODUCTS LAPPING MACHINES THREAD COMPOUNDS

CRANE PACKING COMPANY

New Parts



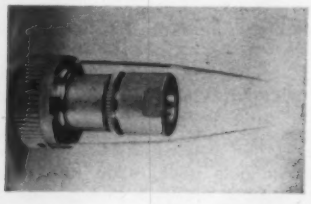
size weighs 0.143 lb. They are available for pressures from 0 to 6000 psi and temperatures from −65 to 1000 F. Valves can be used with many media, including hydraulic fluids, missile fuels and oxidizers, oils, alcohol, air, water, and other media compatible with series 300 stainless steels. Metal-to-metal seals are used. **A. U. Stone & Co. Inc.**, 23 W. 60th St., New York 23, N. Y. D

Circle 647 on Page 19

Miniature Connector

has removable solid-wire lanyard

Model DM9714-3S miniature electrical connector provides three contacts and is equipped with a coupling ring that permits use of a removable solid-wire lanyard. Connector can be installed without the lanyard, which may be at-



tached later. Cable grommet is used on the end of the connector. **Deutsch Co.**, 7000 Avalon Blvd., Los Angeles 3, Calif. L

Circle 648 on Page 19

Electric Starter

for small gasoline engines

Model 850 electric starter is for engines up to and including 4 hp with maximum displacement of about 11 cu in. Starter operates on direct current only, with clockwise rotation. It provides push-button starting, using either in-

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

DISASSEMBLED AND AIRBORNE IN 1 HOUR -- that was a basic design requirement for brakemotors powering portable aircraft hoists. Other essentials included extremely light weight, very high power output per unit of volume and very low level of radio interference. S-K custom engineered the design for a manufacturer of special Air Force equipment and has built many units. Power supply for the brakemotors is 28 volts d-c; hoist must be capable of lifting a load of 10,000 pounds; provision is made in the S-K design for regulating the speed of the hoist when load is being lowered.

PURE SINE WAVES FROM 2 to 2000 CPS are needed in the power supply of a massive vibration exciter with continuous rated force output of 12,500 pounds and capable of attaining accelerations up to 10 g with loads of 975 pounds. Precision measurements are based on sinusoidal table motion. Heart of the machine is the S-K rotary power unit comprising: 75 hp 60 cycle motor; 460 v. d-c generator; 230 v. field exciter; 460 v. variable speed d-c motor; and two pure sine wave alternators, one covering the range from 2-500 cps, the other 500-2000. No capacitors are needed for power factor correction over entire range.

IN AND OUT OF COLD STORAGE go the lift trucks that shuttle back and forth in refrigerated warehouses, passing from temperatures of -38° to normal ambients. Starting with its standard design for electric truck motors, S-K developed a special varnish treatment for the Class B insulation to enable it to withstand the severe moisture condensation encountered. This varnish treatment is used on both drive and pump motors, which have been in daily service for periods as long as five years under severe loading conditions; motors have required little or no maintenance.

Circle 490 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION

SAFETY INDUSTRIES, INC.

P. O. BOX 904 NEW HAVEN, CONN.

MOTORS • GENERATORS • DISK BRAKES • SPECIAL ROTATING AND CONTROL PACKAGES

NEW 2" TO 3⅜" CENTER HYGRADE WORM GEAR SPEED REDUCERS

⅓ TO 5 HORSEPOWER INPUT

4 NEW SIZES | 2.000" CENTERS | 2.375" CENTERS | 2.815" CENTERS | 3.375" CENTERS

6 RATIOS | 10⅓ / 20½ / 30 / 40 / 50 / 60

96 NEW HYGRADE COMBINATIONS

IN STOCK at Your Nearby Foote Bros. Distributor or Factory Warehouse

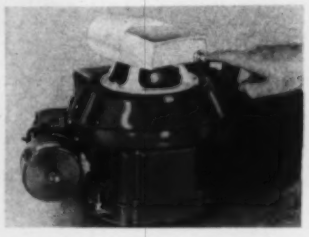
SEE OPPOSITE PAGE FOR MORE DETAILS

FOOTE BROS.
Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Blvd.
Chicago 9, Ill.

New Parts

tegral or remote switch, for gasoline - engine - powered equipment such as pumps, sprayers, industrial scooters, garden tractors, and riding-type power mowers. Starter is powered by a 12-v battery, en-



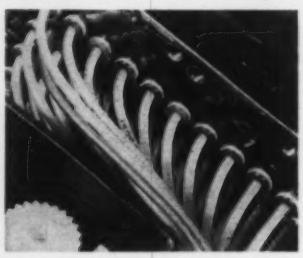
abling repeated starts under normal operations. Magneto Div., **Fairbanks, Morse & Co.**, Beloit, Wis. K

Circle 649 on Page 19

Compression Fittings

withstand pressures to 1200 psi

Presslok nylon compression fittings provide an anticorrosive, positive anchor in hydraulic and pneumatic applications using brass, copper, aluminum, steel, or nylon tubing, without damaging or distorting tubing. Easily installed, the fittings withstand pressures to 1200 psi. Tubing connection clearance can be as little as 1/16-in. from



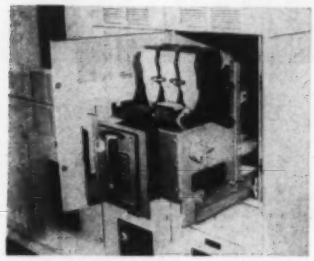
OD of fitting. Fittings are available in seven sizes at 1/16-in. intervals for tubing sizes from ⅛ to ½ in. OD. **Nylon Molding Corp.**, 141 South Ave., Garwood, N. J. D

Circle 650 on Page 19

Circuit Breakers

utilize subassembly construction

K-Line circuit breakers, 600-v units in 225, 600, and 1600-amp frame sizes, are designed for commercial-building, industrial-plant,



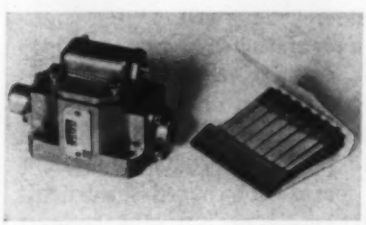
and power-station applications. Motor-driven stored-energy system is provided for electrically actuated models. It stores energy for closure, cutting drain on breaker's secondary circuit. Open breaker design permits complete accessibility of trip units. Escutcheon-mounted, automatic trip indicator shows that breaker has tripped on overcurrent or undervoltage. The line uses six major subassemblies. Subassembly design minimizes parts stocking, facilitates inventory systems, and cuts replacement time. Shown is a K-Line breaker withdrawn from compartment on telescoping, two - stage rails. Switchgear Div., **I-T-E Circuit Breaker Co.**, 19th & Hamilton St., Philadelphia 30, Pa. C

Circle 651 on Page 19

Servo Valve

is dry-coil, two-stage unit

Dry-coil, two-stage electrohydraulic servo valve is designed primarily for aircraft and missile applications requiring hydraulic flow proportional to small electrical input signals. Total weight is 9.3 oz, and envelope dimensions are 3.08 x 1.75 x 1.83 in. Torque motor and hydraulic amplifier are a



separable assembly. This arrangement permits greater flexibility through the use of various second-stage components. Valve is interchangeable with most servo valves

(*Please turn to Page* 178)

NEW 2" TO 3 3/8" CENTER

HYGRADE WORM GEAR SPEED REDUCERS

1/3 TO 5 HORSEPOWER INPUT

Plus Features for Plus Service
• Strong, tough cast iron housings insure exact and permanent gear alignment, rigid bearing support.
• Wide-faced worm gear, made of virgin alloy bronze, on a forged steel gear shaft.
• Alloy steel worm and shaft . . . carburized, hardened and ground.
• Extra capacity ball radial and thrust bearings on worm shaft; tapered roller bearings on worm gear shaft.
• Improved neoprene spring backed lip seals on shafts.
OIL LEVEL
DRAIN

Now—Foote Bros. offers the longer service life, greater capacity-for-size, more compact design and extra quality of famous Hygrade Reducers in 96 new combinations.

Advanced worm gear design and Foote Bros. precision production techniques make these new Hygrade Reducers the most efficient and economical power packages you can buy. And they're easier to select and buy, because Foote Bros. Distributors and Branch Warehouses carry them in stock ready for immediate delivery.

IN STOCK at Your Nearby Foote Bros. Distributor or Factory Warehouse

Write for new Hygrade Bulletin

FOOTE BROS. GEAR AND MACHINE CORPORATION
4567 South Western Blvd.
Chicago 9, Ill.

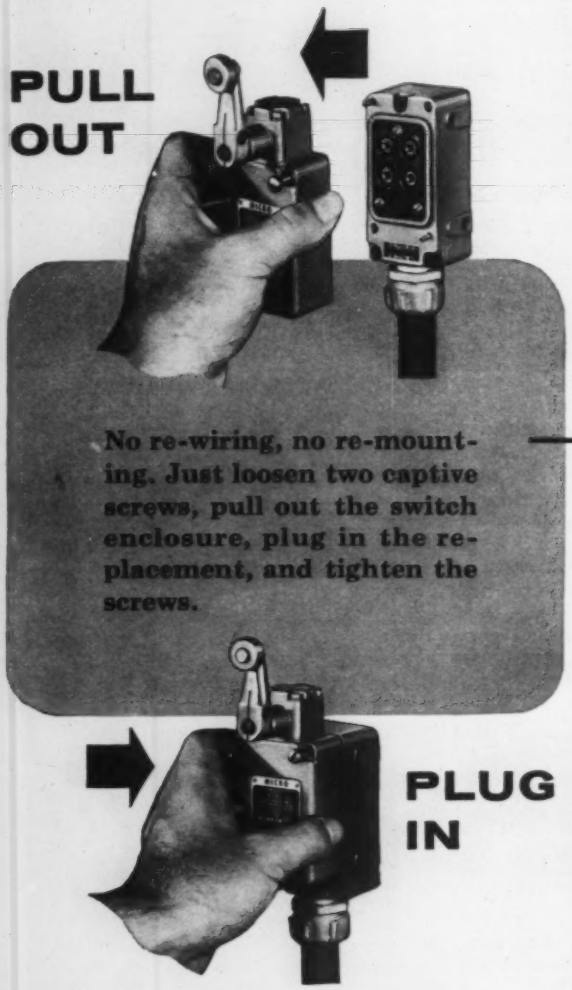
FOOTE BROS.
Better Power Transmission Through Better Gears

Circle 491 on Page 19

MICRO SWITCH Precision

These outstanding NEW precision switches enable design engineers to save space, time, maintenance and installation costs

High quality with reliability has made MICRO SWITCH the leading manufacturer of precision switches with the largest line of switches from which to select. MICRO SWITCH plants and development laboratories are equipped with scientific tools for painstaking precision, quality control and testing techniques. Field Engineering offices blanket the country. There is always a MICRO SWITCH man near you—ready to cooperate on switching problems.


PULL OUT
No re-wiring, no re-mounting. Just loosen two captive screws, pull out the switch enclosure, plug in the replacement, and tighten the screws.
PLUG IN

(Send for Bulletin No. 20)

How you can cut "down time" with this "Plug-in Limit" switch

Here's a real timesaver for users of precision limit switches—a revolutionary new precision limit switch that can be replaced IN SECONDS. The MICRO SWITCH "Plug-in Limit" answers a prime requirement for designers of devices for use on high speed automatic production lines. It offers all the features of rugged construction and precise, long-life operation of the industry-proved MICRO SWITCH "LS" Series. Yet the switch enclosure, including all mechanical and electrical parts, is plugged into the terminal block as easily as a radio tube. Dowel pins assure precise positioning.

Switches have uses unlimited

How to get more pushbutton switches on a panel

MICRO SWITCH Series 100 PB Lighted Pushbutton Switches provide an unusually neat, good looking panel. Their compact mounting allows more switches per panel.

Important features include:

Three types of illuminated signal—

(1) one-color buttons, (2) two colors (lighted singly or in combination) and (3) choice of either of two colors—neither of which is visible when button is unlighted.

Large, easily engraved buttons—

Buttons are large enough to allow two lines of clearly legible engraving.

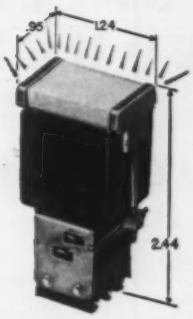
Wide choice of circuitry—

Because separate terminals are provided for each lamp and for each element of the contact structure, these switches permit intermixing of voltages, a-c or d-c current and even combinations of opposing polarities.

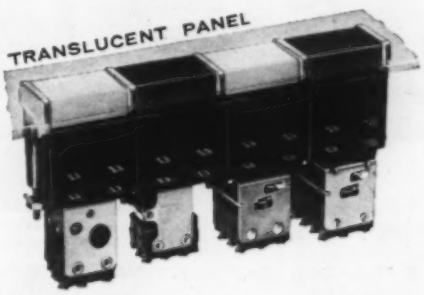
Matching lamp assemblies available—

Matching indicating lamp assemblies are available with the same button and lamp combinations and the same means of mounting as the complete 100 PB switch assembly.

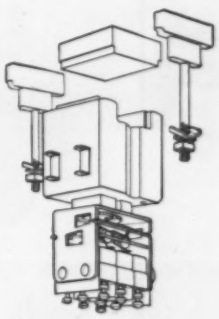
(Send for Data Sheet 143)



Typical switch module on a 3-circuit design.

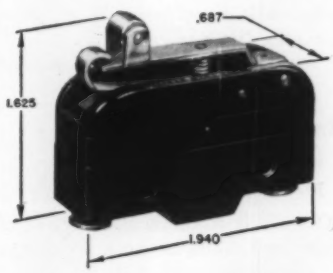


A typical compact assembly of switches in panel slots. Indicates choice of button color and number of circuits.



Exploded view showing switch assembly, button and mounting means.

A roller-lever switch with the stability of pin-plunger switch



A new design in roller-lever actuators is this MICRO SWITCH Type W.

This small, compact roller-lever basic switch is ideal for use of such control mechanisms as radar units, precision machine tools or other devices where precise actuation with little variance in operating points is required.

This Type W switch incorporates a new design in roller lever actuators which gives it an operating stability similar to a pin-plunger switch—low pre-travel, narrow differential travel and close repeatability but also permits exceptionally high overtravel.

The roller is located on top of a double lever. As the roller is depressed, both levers move downward until the switch is actuated. The upper level then proceeds on downward, providing the high overtravel. The limited overtravel given to the snap spring and a low break gives this switch a long, trouble-free mechanical life.

(Send for Data Sheet 127)

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

First in Precision Switching

ROCKFORD

SPEED REDUCERS
(Reduction Gears)
With
OVER-CENTER TYPE CLUTCH

Gear-Tooth Drive

Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

ROCKFORD Speed Reducers incorporate a complete clutch power take-off and reduction gear assembled into one complete unit. They are suitable for the transmission of power from internal combustion engines where out-put shaft speeds required are lower than engine speeds. A heavy-duty, over-center clutch, with gear-tooth drive construction is used. Positive engagement or disengagement position is accomplished by mechanical action of toggle arrangement. Various reduction ratios are available. Standard S.A.E. housing sizes.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER
311 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

CLUTCHES

New Parts

(*Continued from Page 175*)

presently in use. It is recommended for use with supply pressures to 3000 psi and operating temperatures from −65 to 275 F. **Vickers Inc.**, Detroit 32, Mich. H

Circle 652 on Page 19

Thumb Nuts and Screws

are rustproof and corrosion resistant

Die-cast zinc alloy thumb nuts and screws are available in six sizes from ½ to 1⅛ in.; thread sizes range from No. 4 to 7/16 in. Shoulder thumb nuts are available as closed or open-end types. Thumb screws are either one-piece, die-cast units, plain or shoulder type,

or two-piece assemblies of zinc-alloy shoulder thumb nuts and steel machine screws in varying thread sizes and lengths to 4 in. Fasteners are rustproof, corrosion resistant, and permit the application of standard finishes for decorative purposes. Design provides wide heads and deep fluted edges for fast, easy use. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y. D

Circle 653 on Page 19

Miniature Relay

incorporates a permanent magnet

SC relay is 0.359 in. wide, 0.875 in. high, and 0.795 in. deep. It utilizes a permanent magnet to obtain high shock and vibration resistance. Unit remains operative under shocks of 100 g, vibrations of 30 g to 2000 cps, and linear accelerations of 400 g, with no contact openings. Minimum contact pressure is 13 grams. The DPDT relay switches 2 amp at 30 v dc or 1 amp at 115 v ac resistive. Ambient temperature range is −65 to

Help Satisfy the "Low Cost" Requirements of Your Design

GITS

World's Largest Selection of LUBRICATING DEVICES

LUBRIKIT . . . An assortment of 95 oil cups of 29 different types. Gits sales records show these oilers are most used for replacement and maintenance. Contents of each separate bin are clearly described on Inside Cover.

Special Introductory Price
Just $14.95 F.O.B. Factory
Satisfaction or your money back

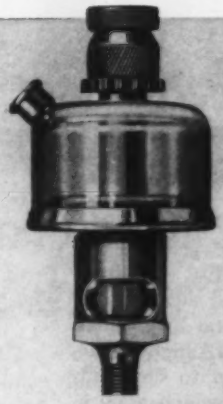
OIL HOLE COVERS

Style R — No. 304 Shoulder Drive

Style G — No. 505 Beaded Drive

Style GB — No. 527 Ball Valve

Style L — No. 1204 Brass Elbow (Threaded)



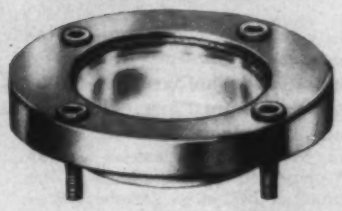
SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

GEAR CASE GAUGES



Screw mounted, to set flush. Glass port is backed with white enameled reflector, to make oil level (in gear case or transmission) readily visible, even in dim light. Style CW — No. 4032.

SIGHT GAUGES

For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

GITS BROS. MFG. CO.

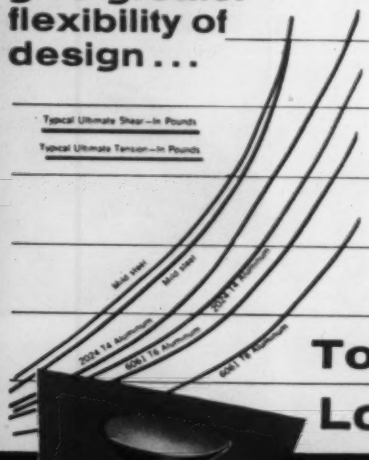
The Standard For Industry For Almost Half A Century

1868-C South Kilbourn Avenue
Chicago 23, Illinois

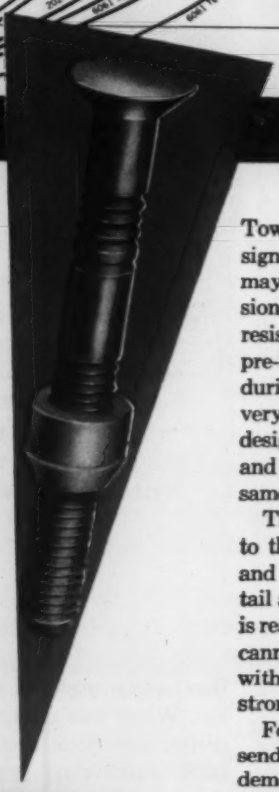
Clip this page for handy "rough reference"

Circle 494 on Page 19

High, uniform tensile pre-load and shear values give greater flexibility of design...



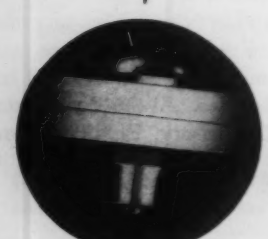
Townsend Lockbolts



Townsend lockbolts* give the designer great flexibility, for they may be used in either shear or tension applications, and have great resistance to fatigue. A high tensile pre-load is imparted to the joint during installation, which gives a very high shear value. No overdesign is necessary, because shear and tensile pre-load values are the same in every joint.

The setting gun swages the collar to the locking grooves on the pin, and breaks off the projecting pin tail as a pre-determined break-load is reached. The gun's cycling action cannot be altered, and even men with no special skill can produce strong, uniform, economical joints.

For more information on Townsend lockbolts, request a complete demonstration right at your desk, or write for Bulletin TL-101. Townsend Company, P. O. Box 237-E, New Brighton, Pa.



The Fastening Authority

Townsend

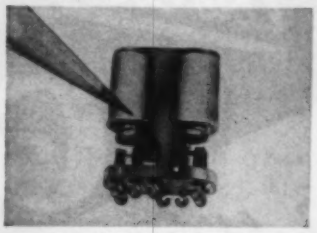
COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

New Parts



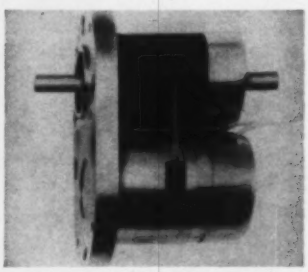
125 C. Relay is furnished with plug-in terminals for printed circuits or miniature receptacles, or with hook-end solder terminals for two No. 24 AWG wires. Plug-in, bracket, or stud mountings are available. **Potter & Brumfield Inc.**, Princeton, Ind. J

Circle 654 on Page 19

Clutch Pack

consists of indexing clutch and electrical transducer

A 100-CP clutch pack consists of a mechanical pulse amplifier indexing clutch, an electrical transducer, servo bracket, and nylon link. Time for both mechanical and electrical delays is predetermined. Mechanical delay is as low as 0.001 sec, electrical delay, 0.0035 sec, and combined delay, 0.0045 sec. Power pack supplies different voltage levels for aircraft and industrial applications. Applications include use in automatic control sys-



tems, electronic computers, data-processing equipment, automatic machines, and photographic equipment. **Digitronics Corp.**, Albertson Avenue, Albertson, L. I., N. Y. D

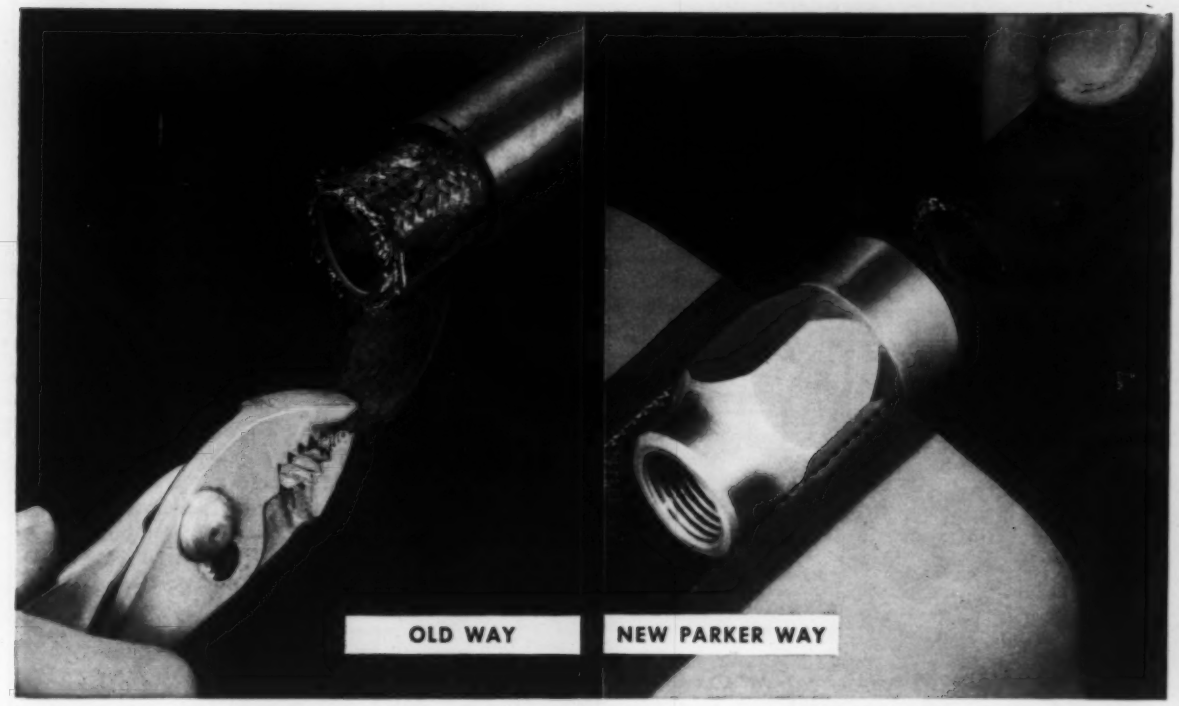
Circle 655 on Page 19

Miniature Bearings

in sizes from 3/16 to ½ in. OD

RMB miniature ball bearings are made to ABEC-1 tolerances. They can be furnished with standard or special radial and axial clearances.

Circle 495 on Page 19



New Parker No-Skive Hoze-lok

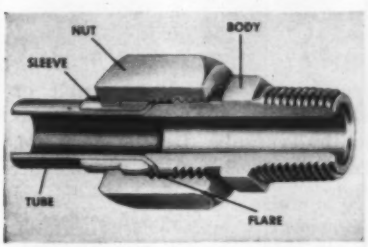
FASTER . . . EASIER . . . RE-USABLE

No more frustrating jobs of stripping off the covers of hydraulic wire-braid, rubber-covered hose! No more ragged hose ends that refuse to enter fitting sockets!

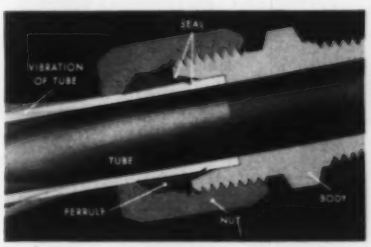
New Parker Hoze-lok Fittings save you all this time and trouble. Skiving of hose covers is *not* necessary. Simply screw the hose (with cover intact) into the socket and then screw the nipple in to complete the make-up. What could be easier . . . or more effective?

Versatile Hoze-lok Fittings are re-usable . . . an important benefit to users of your equipment. Select your fittings from the new series of Hoze-lok styles and sizes, with four different connecting ends and full range of adapters.

Ask your Parker Distributor or mail this coupon today for catalog about Parker Hoze-lok Fittings and for details about Parker Triple-lok and Ferulok.



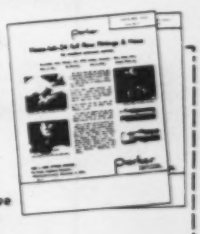
Triple-lok Flare Fittings . . . the easiest, fastest, safest way to tube up even in close quarters. Leakproof even under severe vibration, high pressures. Meet S.A.E. Hydraulic Tube Fittings Standard.



Ferulok Flareless Fittings for high-pressure, heavy-wall tubing. Double seal makes Ferulok leakproof, vibration-proof. You can see the "bite." Meet S.A.E. Hydraulic Flareless Tube Fittings Standard.

TUBE AND HOSE FITTINGS DIVISION

Parker Hannifin
creative leader in fluid systems



TUBE AND HOSE FITTINGS DIVISION
Section 429-V
Parker-Hannifin Corporation,
17325 Euclid Avenue
Cleveland 12, Ohio

Please send:

- ☐ *Hoze-lok* Catalogs 4433, 4434
- ☐ *Triple-lok* Catalog 4310
- ☐ *Ferulok* Catalog 4320

Name_____

Title_____

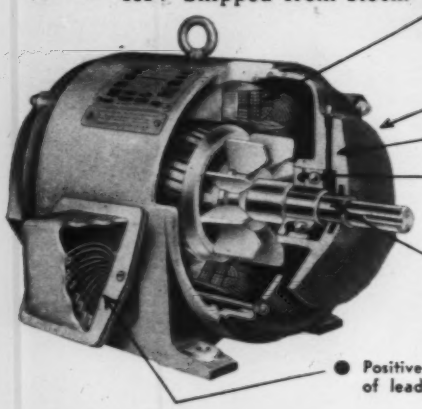
Company_____

Address_____

City_____ State_____

STAMINA of BROOK A.C. MOTORS is no coincidence!

Design is based on over half a century of experience. Built to surpass NEMA Specifications, yet cost no more than ordinary motors. Single and polyphase. All major types. 1 to 600 HP. Shipped from stock.



- Long-life windings are triple impregnated and baked.
- Internally-ribbed, shock resistant iron frame.
- Generous bearing lubrication capacity.
- Bearings two sizes larger than customary; yet, still replaceable from any standard bearing stock.
- High tensile steel, precision ground shaft and balanced rotor assembly.
- Positive identification of leads.

SINCE 1904

world's most respected motor

BROOK MOTOR CORPORATION

3553 W. PETERSON AVE., CHICAGO 45, ILLINOIS

BROOK MOTOR CORPORATION

Factory Representative, Warehouses, Dealers, Service Stations, in Major Cities.

Circle 497 on Page 19

The Mechanical Seal That Beats Corrosion, Temperatures, Pressures and Speeds

DURA SEAL

Because Dura Seal rotary mechanical seals are made of any machineable metal alloy, they are engineered to provide perfect sealing in the presence of highly corrosive process fluids at high speeds, pressures and temperatures.

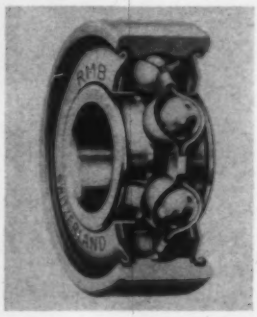
WRITE TODAY FOR YOUR COPY OF THIS NEW BOOKLET ON MECHANICAL SEALING— illustrating and describing Types of Dura Seals adaptable for meeting various sealing conditions.

DURAMETALLIC CORPORATION

KALAMAZOO, MICHIGAN

Circle 498 on Page 19

New Parts



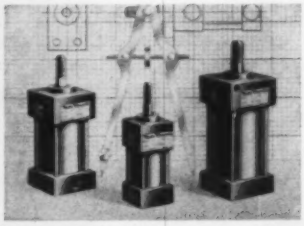
Applications include use in cam followers, potentiometers, and electric motors. Wide range of sizes is available from 3/16 to ½ in. OD. **Landis & Gyr Inc.**, 45 W. 45th St., New York 36, N. Y. D

Circle 656 on Page 19

Small Cylinders

are heavy-duty units for air and hydraulic use

Tom Thumb cylinders are small, heavy-duty units with minimum mounting dimensions. They are available in eight mounting styles with bore sizes of ¾, 1, and 1⅛ in. Pressure ratings are 200 psi, air, and 2000 psi, hydraulic service. Cylinders are available in any



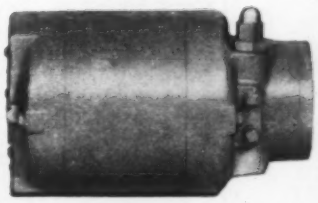
length stroke in either double or single-acting spring return. **Pneumatic-Hydraulic Development Co. Inc.**, P. O. Box 943, Ft. Wayne, Ind. J

Circle 657 on Page 19

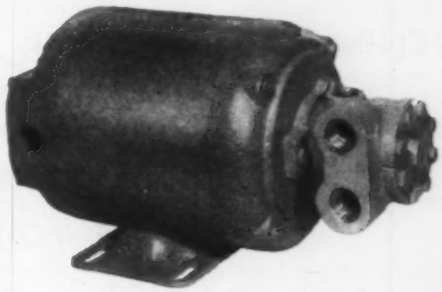
AC-Motor Power Supply

gives adjustable-speed operation

Cycle Varier produces infinitely adjustable speeds in one or a group of standard ac motors. System supplies adjustable-frequency current to control the speed of slave motors. All sizes of ac motors and gearmotors are controlled in unison and in proportion from the single source. A 500 per

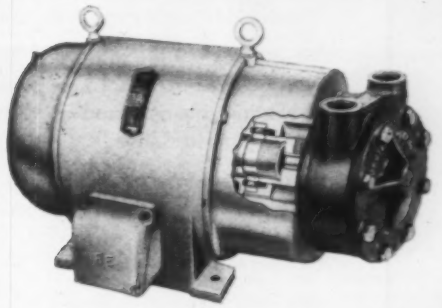


1



2

3 NEW TUTHILL close coupled pump and motor units



3

Save space, Save weight, Cut costs

Now TUTHILL offers three pump and motor combinations developed specifically for applications where space or weight are at a premium. Furnished in a wide variety of sizes and styles, one of these combinations can provide savings in hydraulic, oil burning, lubrication or other services.

The small size of these combinations solves design problems. By reducing weight they cut shipping charges. The elimination of couplings, adapters and bases means lower costs. And even more important savings are often made through the simplification of installation procedures.

Available from Stock

A wide variety of combinations are available immediately from stock, in either large or small quantities.

For example, Number 1 above is TUTHILL'S famous POWERMITE—a combination in which pump and motor are incorporated in one unit which takes up no more space than a standard electric motor (the POWERMITE shown measures only 3⅞" x 7½").

Originally restricted to large quantity applications some POWERMITE models are now available from stock for small quantity orders. The unit shown is rated for 16 GPH at 350 PSI.

For other small quantity applications TUTHILL provides a complete selection of close coupled units with the pump mounted directly on the motor. Numbers 2 and 3 above are typical.

For applications, such as hydraulics which require smaller pumps, units such as Number 2 above provide outstanding advantages. Normally they can reduce space required for pump and motor by at least 6 inches, and cut weight by several pounds. Capacities range from 20 to 300 GPH. Pumps are available for pressures up to 1500 PSI.

Larger pump and motor combinations, such as Number 3 above, can be provided with capacities up to 50 GPM, for pressures up to 400 PSI.

If you are trying to put a pump and motor into a small space, TUTHILL has the answer. Write for details.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From 1 to 200 GPM; for Pressures to 1500 PSI; Speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

Canadian Affiliate:
Ingersoll Machine & Tool Co., Ltd.
Ingersoll, Ontario, Canada

PUMPS FOR YOUR PURPOSE

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois

☐ Please forward complete information on TUTHILL close-coupled Pump and Motor Units for_____GPH at_____PSI.

☐ Please have your representative call.

NAME_____TITLE_____

COMPANY_____

STREET_____

CITY_____

STATE_____

DEPENDABLE AIR POWER

CAN IMPROVE THE

Efficiency

OF YOUR PRODUCT

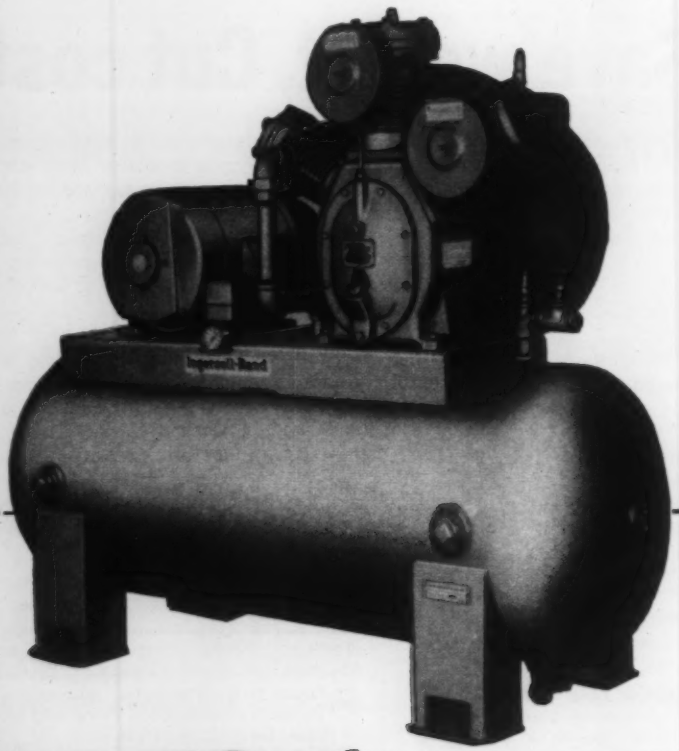
When operation of your equipment hinges on a dependable source of air, get the best compressor. It will add quality and efficiency to your product.

Year after year, since 1878, Ingersoll-Rand air compressors have set new standards of dependable operation through modern design, engineering and production facilities.

Bare, baseplate or receiver mounted air compressors can be supplied to meet your requirements.

Packaged air-cooled compressors—½ through 20 horsepower

Other compressors to 6000 horsepower



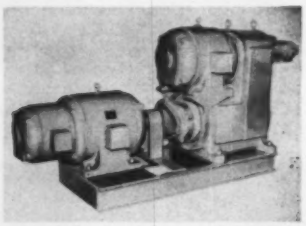
Ingersoll-Rand

11 Broadway, New York 4, N.Y.

3-596

New Parts

cent frequency range permits 5:1 speed variation. System is available for manual, remote, or automatic control. Unit consists of a frequency changer, driven by a mechanical adjustable-speed drive



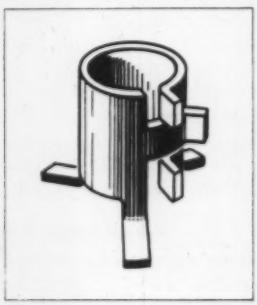
of either open or enclosed (shown) design. Applications include synchronization of interrelated equipment, splitting the drive load on conveyors, and converting machine tools from constant to adjustable speed. **Electra Motors Inc.,** 1110 Lemon St., Anaheim, Calif. L

Circle 658 on Page 19

Spring Clip

grips plastic stud for flexible mount

Three compression tabs are provided at the side of this spring clip. As they are squeezed together, the ring expands, is slipped over the plastic stud, and released. Three small barbs inside the ring



grip the plastic stud to provide flexible, firm retention. **Tinnerman Products Inc.,** P. O. Box 6688, Cleveland, Ohio. F

Circle 659 on Page 19

Permanent-Magnet Alternator

miniature unit has flexible design

Miniature permanent magnet alternator is only 0.990 in. OD, 1 27/32 in. long, and weighs 4 oz. Flexible design permits modifica-

Circle 500 on Page 19

PRODUCT-DESIGN MEMOS FROM DUREZ

Heavy-duty parts
Making epoxies flame-resistant

Metallized phenolics

Chrysler Corporation

Rugged

Got a job that's "too tough for phenolics"?

You might never think of phenolic for a part like this Chrysler-engineered automotive oil-pump gear—subject to wear, heat, friction, constant oil immersion.

But you'd be reckoning without the ruggedness of a new phenolic, *Durez 16771*.

Parts molded from this glass-fiber-filled compound have a flexural strength of 20,000 psi, compressive strength of 16,500 psi. Their tensile strength is 7,000 psi. Modulus of elasticity in tension is 3.0×10^6 psi. What's more, the heat distortion point of these parts is up around 600° F.

Payoff • These properties, plus excellent resistance to oil, water, and acid, made Durez 16771 appear to have some of the properties needed for the Chrysler oil-pump gear. After extensive experimenting and testing, Chrysler engineers developed the plastic gear to replace the usual metal part.

Results: *new gears of Durez 16771 outwear metal gears nearly 3 to 1—show no performance-affecting wear after 200,000 miles; save about two-thirds of the cost of metal gears; run more quietly.*

For a data sheet describing this high-strength phenolic, check opposite "16771" on the coupon.

How to make epoxies resist flame

Your epoxy laminates and castings will shrug off heat, moisture—even fire—if you cure them with a new Durez product called HET® Anhydride.

In the picture that follows, the laminate cured with a conventional hardener ignites in less than 30 seconds and burns to destruction in about 3 minutes. Exposed to a similar flame source for the same time, a HET-cured laminate snuffs itself out as soon as the flame source is removed.

This leads to some interesting possibilities. For instance, you can now make glass-reinforced laminates that keep practically all their flexural strength, *even when heated within the 300-350° F range.*

You can make potting resins that retain room-temperature electrical properties at high humidities *and at temperatures above 300° F*—and won't feed a fire.

For easier casting or wet layup, you need not handle HET Anhydride hot. You can mix it with another anhydride to form a curing system that *stays liquid at room temperature.* Toxicity is very low.

If you'd like complete information on HET Anhydride, methods of use, and properties of cured resins, check the coupon for Bulletins 19 and 43.

Bright idea

Next time you want to put a bright reflective surface on a part, think of *metallized phenolic.* It may save you a costly production step.

American Optical Company

For instance, this housing for a microscope lamp requires a mirror to focus the light.

To sidestep the cost of a custom-made mirror, the housing is molded of Durez phenolic. Then an aluminum mirror is deposited right on the plastic by vacuum evaporation.

This is easy to do with the Durez compound chosen for this part. It provides a good hard surface for metallizing. It incorporates other wanted properties: high impact strength and low thermal conductivity.

You're on sure ground when you base bright ideas like this on phenolics. They give you a bigger choice of controlled properties than any other material in their class. You can select the right balance from *more than 150 Durez compounds.*

To take a fresh look at today's phenolics, just check the coupon for a new four-page bulletin describing some typical Durez molding compounds and what you can do with them.

For more information on Durez materials mentioned above, check here:

- ☐ High-impact Durez 16771
- ☐ HET Anhydride—Bulletins 19 and 43
- ☐ Phenolic molding compounds—descriptive bulletin

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

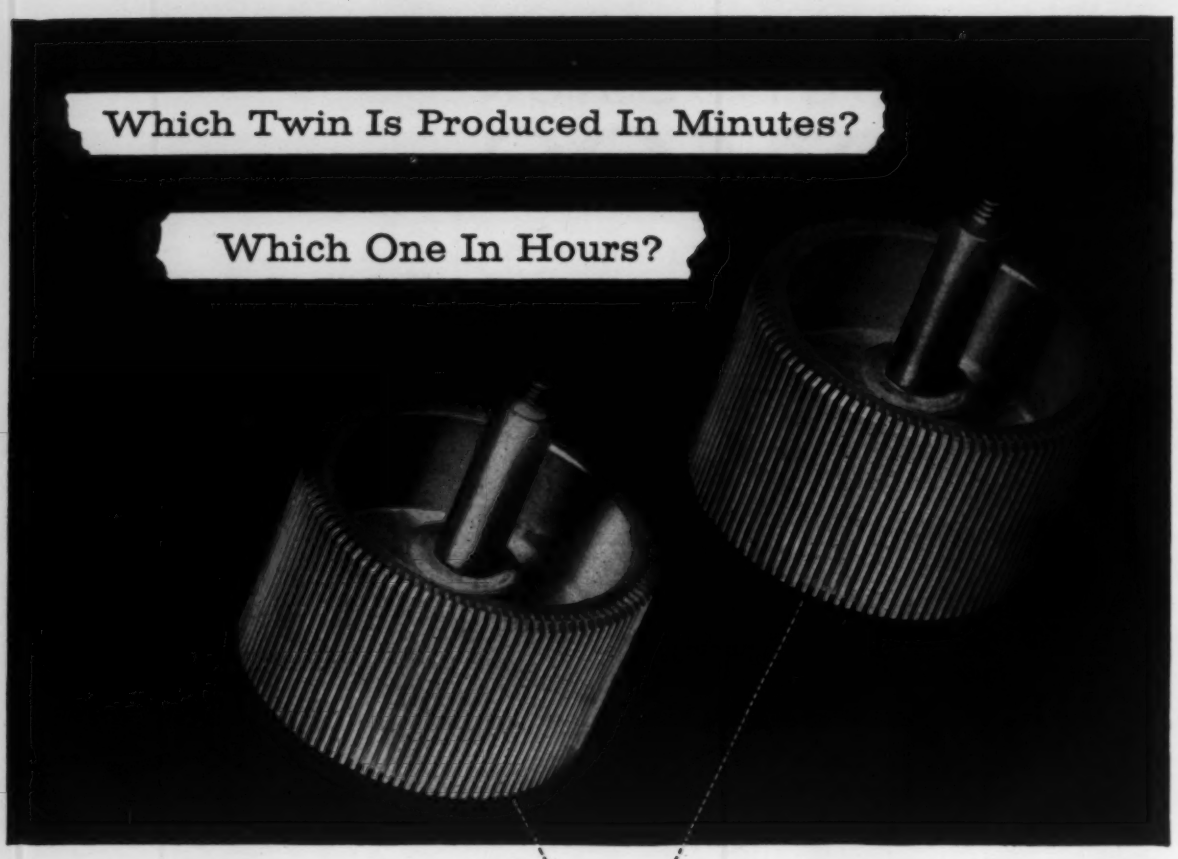
DUREZ® HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
501 Walck Road, North Tonawanda, N. Y.

Circle 501 on Page 19

Which Twin Is Produced In Minutes?

Which One In Hours?



These parts are identical. One, however, is produced in minutes, the other in hours. Parker-engineered die casting makes the difference.

Formerly, this part (shown left above) was machined from the solid. The threaded steel shank was inserted in a separate operation. Numbers on the face (not shown) had to be stamped . . . still another operation. *Total production time per piece was measured in hours.*

Now, this same part, including the steel insert and the face numbers, is produced as a unit by Parker-engineered die casting. Trimming of gate and fins is the only secondary operation. *Total production time per piece is now measured in minutes.*

Here is just another example of the way Parker-engineered die castings save you money.

This skill and experience can solve problems—and save money—on *your* components parts. Just call the nearest Parker sales engineer or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER SALES ENGINEERS

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

CINCINNATI 14, Ohio
William H. Broxterman • 2430 Central Parkway

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F. Marsh • 35 Chestnut Street

LONG BEACH 11, California
R. W. Fletcher • Loomis Avenue

PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue

ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

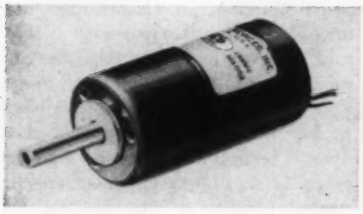
WILTON, Conn.
Girard L. Palmer • Belden Hill Road

WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS

Circle 502 on Page 19



tion of output voltages and frequencies to specific application requirements. Alternator is available in one, two, or three-phase output with various frequency ranges. A six-pole model develops 350 cycles, 14 v, and 80 ma at 7000 rpm with less than 5 per cent distortion. Unit meets rigid military specifications. **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N. H. B

Circle 660 on Page 19

V-Belt

for heavy-duty use on industrial drives

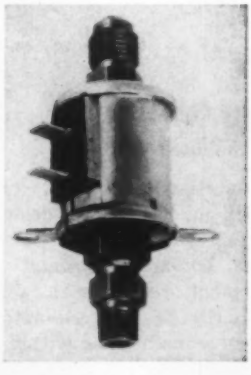
Condor length stabilized V-belt construction eliminates V-belt whip and other causes of belt turnover and failure. Redesigned belt compression area and repositioned strength members provide excellent lateral and longitudinal stability. Belt is constructed of high-tensile, high-strength synthetic fabrics, and is preformed before vulcanization. **Manhattan Rubber Div.**, Raybestos-Manhattan Inc., Passaic, N. J. C

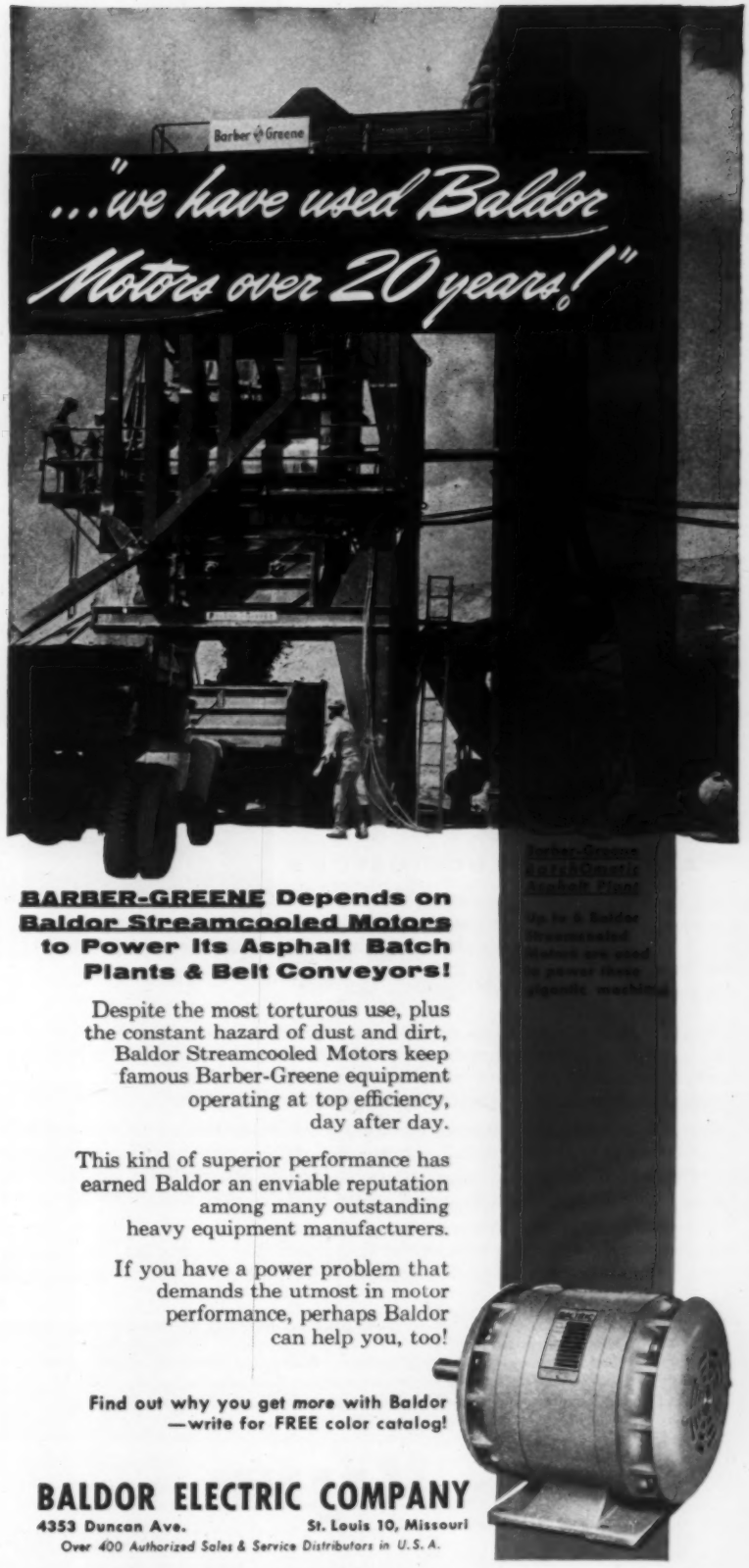
Circle 661 on Page 19

Miniature Valve

for use on air, water, or oil

This miniature valve conducts flow straight through the solenoid arm-





BARBER-GREENE Depends on Baldor Streamcooled Motors to Power Its Asphalt Batch Plants & Belt Conveyors!

Despite the most torturous use, plus the constant hazard of dust and dirt, Baldor Streamcooled Motors keep famous Barber-Greene equipment operating at top efficiency, day after day.

This kind of superior performance has earned Baldor an enviable reputation among many outstanding heavy equipment manufacturers.

If you have a power problem that demands the utmost in motor performance, perhaps Baldor can help you, too!

Find out why you get *more* with Baldor —write for FREE color catalog!

BALDOR ELECTRIC COMPANY

4353 Duncan Ave. **St. Louis 10, Missouri**

Over 400 Authorized Sales & Service Distributors in U.S.A.

District Offices: Atlanta • Chicago • Cincinnati • Cleveland • Dallas • Des Moines • Detroit • Indianapolis Litchfield, Conn. • Los Angeles • Milwaukee • Minneapolis • New Orleans • New York • N. Kansas City, Mo. Oakland • Philadelphia • Portland, Ore.

Circle 503 on Page 19

Specify
BIJUR
AUTOMATIC LUBRICATORS

For DSR
DESIGN, SERVICE AND RESEARCH
are part of every Bijur System

Consider Design – All Bijur pumps are designed to be an integral part of your equipment not a cumbersome attachment. Compact modern designs permit easy adaptation, enabling operation of the pump by means of gear, belt or chain drive or independently operated by electrical or hydraulic set-ups.

How you benefit – Custom-engineered Bijur automatic lubricating systems save production time and repair bills. Down-time and fire risks are sharply reduced. Costly hand oiling is eliminated and every bearing gets the right amount of oil when needed – there's no chance of under oiling or over oiling.

Day-in, day-out Bijur Systems are proving their value to designers, plant engineers and production men on the equipment they design, use, or manufacture. Write today for all the facts about Bijur automatic lubricating systems!

BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

BIJUR
LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

4341

Circle 504 on Page 19

New Parts

ature housing. It resists moisture, and is suitable for use with edibles and corrosive materials. Several models are available with monel and stainless-steel parts. Solenoids in all models are encapsulated in epoxy resins. Variety of end fittings is available to meet specific needs. Valve is for use on air, water, or oil. **Fulton-Sylphon Div.,** Robertshaw-Fulton Controls Co., Box 400, Knoxville 1, Tenn. A

Circle 662 on Page 19

Explosionproof Switches

have double conduit openings

Designated EX 1 series, new explosionproof switches with double conduit openings have application in installations that require through wiring. They are approved for hazardous atmospheres of Class I, Group C, and Group D; and Class II, Group E, Group F, and Group G. All switches have adjustable roller-arm actuators with nonsparking rollers. Conduit

openings are available for use with either ½ or ¾-in. diam conduit. Variations include SPST and DPDT contact arrangements, other sizes of conduit openings, and a wide range of electrical ratings. **Micro Switch,** Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. K

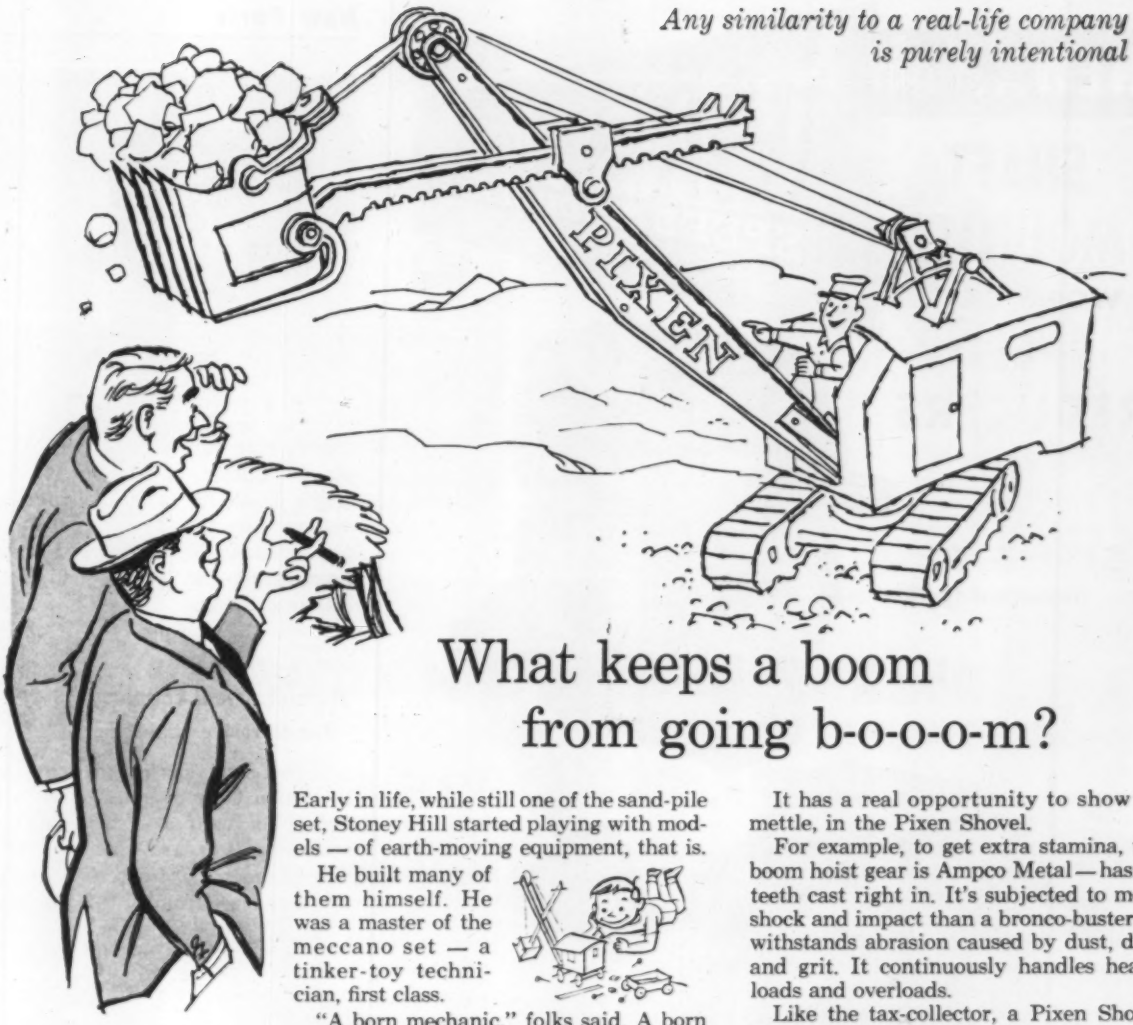
Circle 663 on Page 19

Rotary Converter

is mounted vertically

This vertically mounted converter is 11¼ in. tall, and is designed as a dc-ac converter for test equipment, boats or ground mobile equipment requiring a small ac source. Precise 60-cycle output frequency is maintained within a frac-

Any similarity to a real-life company is purely intentional



What keeps a boom from going b-o-o-o-m?

Early in life, while still one of the sand-pile set, Stoney Hill started playing with models — of earth-moving equipment, that is.

He built many of them himself. He was a master of the meccano set — a tinker-toy technician, first class.

"A born mechanic," folks said. A born manufacturer, he turned out to be.

Today, he builds earth-moving equipment for real — shovels, draglines, backhoes, bulldozers, scrapers. You want to move a mountain, you talk to Stoney Hill.

And his best mountain-mover is the Pixen Shovel. What a brute! An ordinary hill is little more than a mouthful to that baby. It can level anything in sight.

It can bang against boulders. Sink into sand. Maneuver in mud. Make like a mountain goat on some pretty steep grades. And still come back for more, day in, day out.

Stoney designed it that way. One thing he insisted on was that critical parts be made out of Ampco Metal. As you know (we hope), Ampco Metal is a whole series of copper-base alloys specially engineered to resist all forms of wear and corrosion.

It has a real opportunity to show its mettle, in the Pixen Shovel.

For example, to get extra stamina, the boom hoist gear is Ampco Metal — has its teeth cast right in. It's subjected to more shock and impact than a bronco-buster. It withstands abrasion caused by dust, dirt, and grit. It continuously handles heavy loads and overloads.

Like the tax-collector, a Pixen Shovel gets anywhere there's paydirt. Track-roller bushings cast of Ampco Metal help minimize breakdowns and replacements due to friction, shock, and abrasion.

Just to make sure the Pixen Shovel doesn't "blow its top" when it gets all shook up, Stoney has attached the cab to the frame with a king-pin bushing of Ampco Metal. The turn-table roller bushing is Ampco Metal, also. And so are the saddle plates. No use taking chances.

Perhaps *your* bread and butter is screw machines, not shovels. Whatever it is — if wear (or corrosion) is a problem, ask an Ampco field engineer to help you dig up a solution.

And write today for Bulletin 33 for more facts on "the metal without an equal." *Ampco Metal, Inc., Dept. MD-1, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, California).*

AMPCO® METAL

The metal without an equal

0-10

NEW... from WINSMITH SPEED REDUCERS

SHAFT MOUNTED WORM GEAR SPEED REDUCERS

SERIES "ST"
Torque Arm Type

SERIES "SF"
Flange Mounted Type

Now you can specify Winsmith performance, dependability and economy for applications requiring a shaft mounted speed reducer.

The new Winsmith "ST" and "SF" series require less space than conventional models because they eliminate the need for couplings and bed plates. Both series are currently available in three sizes... in ratios from 7½:1 to 77:1... horsepower from .63 to 8.82... maximum output torque range from 816 to 7678 in. lbs.

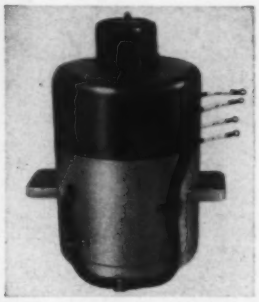
These new shaft mounted models also embody all the advanced engineering and construction features that make Winsmith Speed Reducers first choice for any application from 1/100 to 85 h.p.

WRITE... FOR NEW CATALOG

For all the facts and complete technical data on Winsmith Shaft Mounted, Worm Gear Speed Reducers, write today—on your company letterhead, please—for Catalog No. SM-57.

WINSMITH, INC. 16 Elton Street, Springville, (Erie County), N. Y.

New Parts



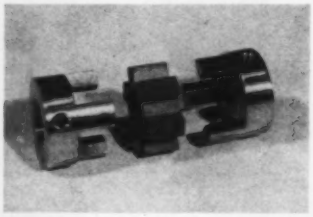
tion of a cycle as attached speed governor holds speed at 3600 rpm. Unit is both fungus and corrosion-proof. Output is 350 w, 115 v, single phase, 60 cycle, of two-wire design. Input is 24 v dc, 3 amp per terminal, 2 field amp. **Kato Engineering Co.**, 1415 First Ave., Mankato, Minn. J

Circle 664 on Page 19

Stainless-Steel Coupling

for corrosive atmospheres

Stainless-steel shaft coupling has a cushion body of glass-reinforced Teflon for wear and corrosion resistance. It is available for fractional-horsepower motors. Standard bore sizes from ¼ to ¾ in. are



furnished from stock; other sizes are available on order. **Eco Engineering Co.**, 12 New York Ave., Newark 1, N. J. D

Circle 665 on Page 19

Electric Motor

operates valves, dampers, and other controlled devices

New electric motor operates various valves, dampers, louvers, rheostats, adjustable transformers, mechanical speed changers, and burner firing controls, in accordance with signals generated by electric control instruments. Two models, each having two-position, floating, or proportional control forms, are available in various speeds and

Tapered for positive suspension.
High radial sealing surface.
"Tongue and groove" for easy installation.
Clearance for radial motion.

KOPPERS HUHN CARBON RING

Reduces Steam Loss as much as 90%!

The unique design of Koppers Huhn Carbon Ring reduces steam loss far below the customary 1% loss of labyrinths and carbon garter spring rings. Huhn Carbon Ring keeps steam loss as low as ¼ of 1% . . . often as little as 1/10 of 1%. Using your own figures for steam costs, you can easily discover how much Koppers Huhn Carbon Rings can save you annually.

The design assures you continuous radial sealing . . . because a radial sealing surface is always forced against a chamber wall. Automatic suspension . . . even during shutdowns . . . prevents shaft contact, reduces wear, and prolongs life. The Huhn Carbon Ring operates with peak efficiency at highest shaft surface speeds and highest operating temperatures.

Koppers Huhn Carbon Ring replaces labyrinths and carbon garter spring rings in compressors, and steam and water turbines. Steam savings alone often pay within a year for the cost of replacement. Discover now how Huhn Carbon Rings reduce steam and fluid losses and minimize operating, maintenance and repair costs. Write: KOPPERS COMPANY, INC., *Piston Ring and Seal Dept.*, 2301 Hamburg St., Baltimore 3, Md.

Koppers Company, Inc.
Metal Products Division
Piston Ring and Seal Dept.

***Engineered* Products**
Sold with *Service*

KOPPERS®

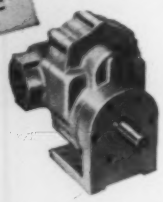
MECHANICAL SHAFT SEALS

Circle 507 on Page 19

ADEL *Industrial Hydraulic Equipment*

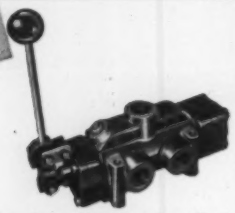
for PEAK PERFORMANCE ADEL Hydraulic Valves and Pumps are setting new and ever higher standards for precision in manufacturing and efficient performance in operation. Following are but a few of the wide variety of models to meet all operating conditions.

GEAR-TYPE HYDRAULIC PUMPS



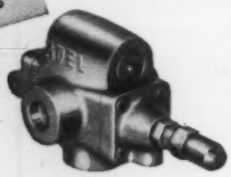
For 1000 psi service with rated capacities at 1800 rpm of from 1.5 to 46.8 gpm.

DIRECTIONAL CONTROL VALVES



4-way valves with spring-centered, spring-offset, and 1, 2, or 3 position detent action. 1500 psi. Flows to 28 gpm.

BY-PASS VALVES



Relief, Sequence and Unloading valves. Direct or remote operation, 50 to 1500 psi range.

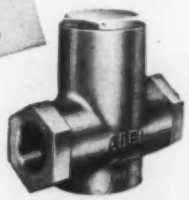
VOLUME (FLOW) CONTROL VALVES

Compensated type maintains constant flow over wide differential pressure range. No drain line required. 1500 psi.

PILOT VALVES

2 or 3 position detent. With or without dog or lever. Can be used as 4-way valve in small circuits. 1000 psi.

CHECK VALVES



Valves allow free flow in one direction only. Many variations available. 3000 psi.

Reliability

ADEL PRECISION PRODUCTS

A DIVISION OF GENERAL METALS CORPORATION

HUNTINGTON, WEST VIRGINIA

Manufacturers of MARINE & INDUSTRIAL HYDRAULIC CONTROL EQUIPMENT

DISTRIBUTORS:

ARIZONA
Air-Draulics Company
Phoenix, Arizona

CALIFORNIA
Haskel Engineering & Supply Co.
Glendale 4, California
Haskel Engineering & Supply Co.
San Francisco 3, California

CONNECTICUT
Air & Hydraulic Engineering Co.
New Haven, Connecticut

INDIANA
The Neff Engineering Co.
Fort Wayne 3, Indiana

MICHIGAN
Industrial Air & Hydraulic Equipment Company
Detroit 15, Michigan
Hydraulic Equipment Co.
Saginaw, Michigan

MINNESOTA
Ringerud Equipment Co.
Edina Branch
Minneapolis, Minnesota

MISSOURI
Corby Supply Company
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Independence, Missouri

NEW YORK
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PENNSYLVANIA
Frank T. Donnelly Company
Pittsburgh 38, Pennsylvania

RHODE ISLAND
Lincoln Supply Company
Pawtucket, Rhode Island

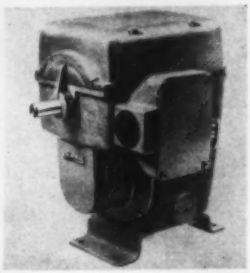
TEXAS
Air-Draulic Equipment Company
Houston, Texas

UTAH
Robert Taylor & Sons
Salt Lake City 10, Utah

WASHINGTON
Russ Chamberlin Company
Seattle, Washington

New Parts

torques. Series 831E2 has a rated output torque from 1.5 to 31.2 lb-ft and Series 831E1 torque rating is from 3.1 to 62.5 lb-ft. Two-position and floating control models can be adjusted for 35 to 335-deg rotation, and proportional model for 35 to 100-deg rotation without



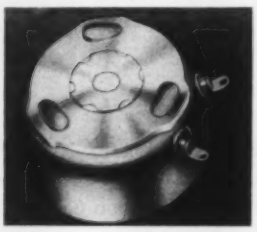
loss of reversing rotation. Voltage and frequency of the unit are 115 or 230 v, 50 or 60 cycles, or 115 v, 25 cycles. **Brown Instruments Div.,** Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa. E

Circle 666 on Page 19

Rotary Solenoids

resist high impact shocks

Ledex rotary solenoids have solder terminals of compression glass, insulated to provide high resistance to tensile and impact shocks. Use of the terminals eliminates the need for a secondary terminal with



pigtail-type leads, as well as the necessity for splicing to coil leads. **G. H. Leland Inc.,** 123 Webster St., Dayton 2, Ohio. G

Circle 667 on Page 19

Variable-Area Diaphragm

actuates fluid-handling valves

Compact enough to install in a small valve motor operated by manifold pressure or other fluctuating pressure sources, this variable-area diaphragm actuates but-

Yes!...it's ALL STEEL

HP RANGE:
½ to 50 hp

RATIOS:
4:1—14:1—24:1 (or 20:1)

OUTPUT SPEED RANGE:
420 to 5 rpm

TORQUE RATINGS:
up to 31,500 lb-in

FALK
ALL STEEL
Shaft Mounted Drive

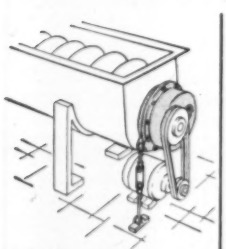
...Steel can "take it"!

STEEL frame ...of fabricated plate supports all rotating elements—provides double the ability of iron to maintain vital alignment of revolving elements, even under shock load or external impact.

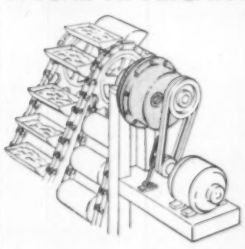
STEEL housing...will not fracture, serves only as protective cover and lubricant reservoir. Therefore, lubricant supply is safeguarded.

STEEL tie-rod and straddle-mounted tie rod brackets...are fastened to heavy steel frame by steel bolts in double shear.

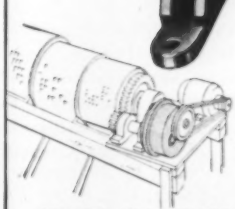
A FEW TYPICAL APPLICATIONS



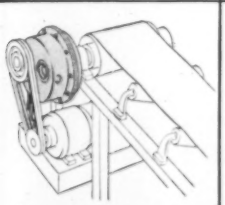
SCREW CONVEYOR



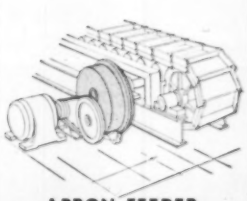
BUCKET ELEVATOR



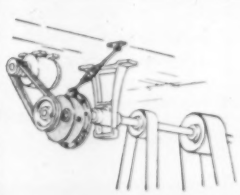
GRAVEL CLASSIFIER



BELT CONVEYOR



APRON FEEDER



LINE SHAFTING

DELIVERIES TO MEET YOUR REQUIREMENTS

Off-the-shelf delivery from your Authorized Falk Distributor. *Shipment from factory or warehouse stocks* within 72 hours after receipt of your order.

Write for Bulletin 7100

THE FALK CORPORATION, 3001 W. CANAL ST., MILWAUKEE 1, WIS.

Representatives and Distributors in Most Principal Cities

Manufacturers of Quality Gear Drives and Flexible Shaft Couplings

Circle 509 on Page 19

FALK

...a good name in industry

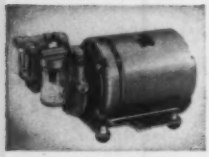
GAST

Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

Provide oil-free air blast with any of the carbon-vane

GAST rotary vane AIR PUMPS

Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.



Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-P Benton Harbor, Michigan.

*Standard oil-lubricated models also available.

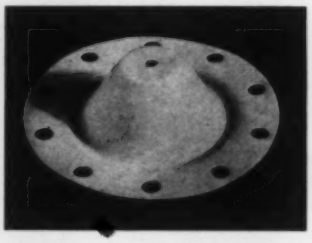
SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY

"Air may be your answer!"

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

New Parts



terfly, plug, louvre-type and other fluid-handling valves with excellent stability. Diaphragm piston seal is self-compensating and operates as a ratio-controller. Effective area changes in a predetermined way with stroke, increasing one way and decreasing the other. Variable-area diaphragm seal, incorporated in a valve motor, provides smooth, stable control over varying pressure changes. As loading pressure on variable-area seal is increased, actuating action becomes less sensitive. **Bellofram Corp.,** Blanchard Rd., Burlington, Mass. B

Circle 668 on Page 19

Cement

has sealing range from 400-450 C

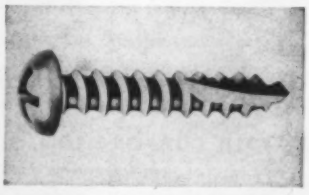
Pyroceram brand cement seals most glasses, including lead, lime, and barium-flint types, ceramics to glass, ceramics and metal to glass, and metal to metal. Materials to be sealed must have an expansion between 85 and 110 x 10^{-7} inch per inch per deg C and must be able to withstand 400-450 C sealing temperature. **Corning Glass Works,** Corning, N. Y. D

Circle 669 on Page 19

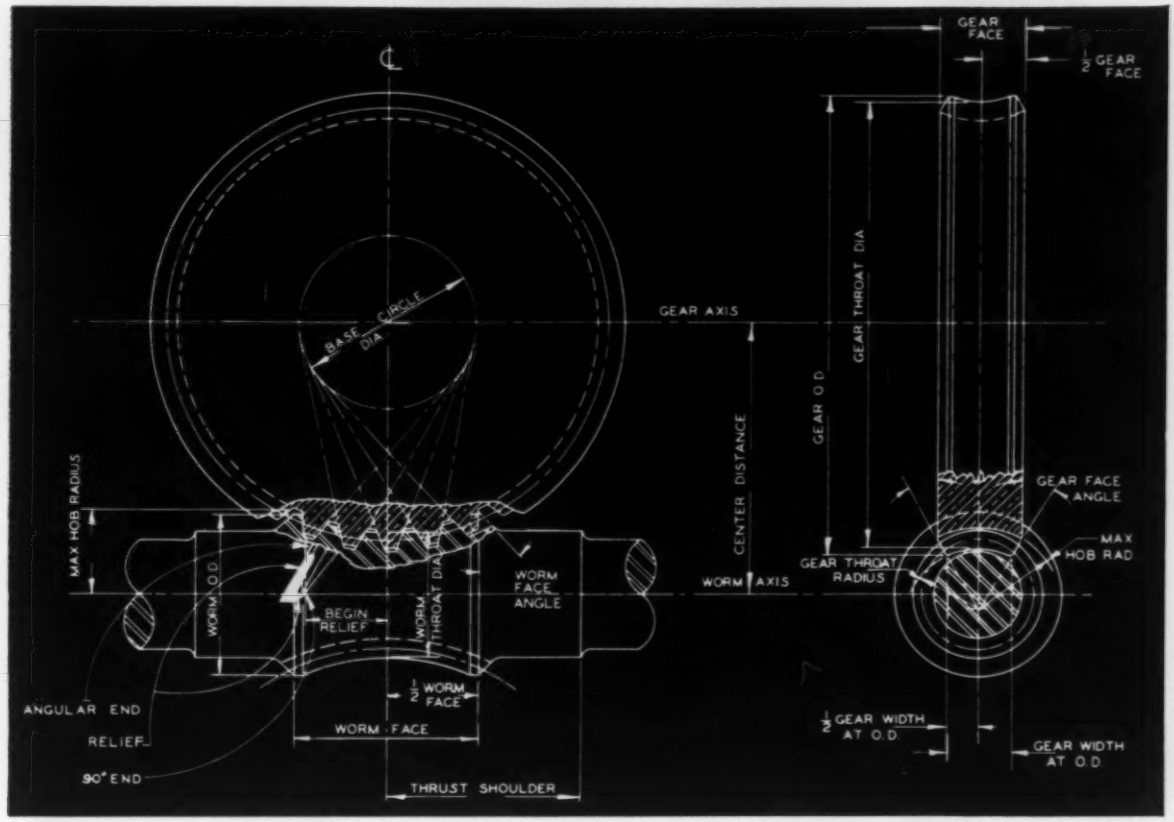
Wood Screw

drills own hole as it is driven

Drill Screw drills and drives with no pilot hole at a lower driving torque than a wood screw with predrilled hole. It does not crack



WORM GEAR DESIGN . . . *Bulletin #200*



Bulletin 200 has 20 pages crammed with 38 formulae, such as the Formula for Class I AGMA Horsepower Rating:

$$P = K_s K_m K_v \frac{n}{mg}$$

Step-by-step instructions, with typical examples, enable you to quickly determine the size worm gearset you need to meet any horsepower and service required.

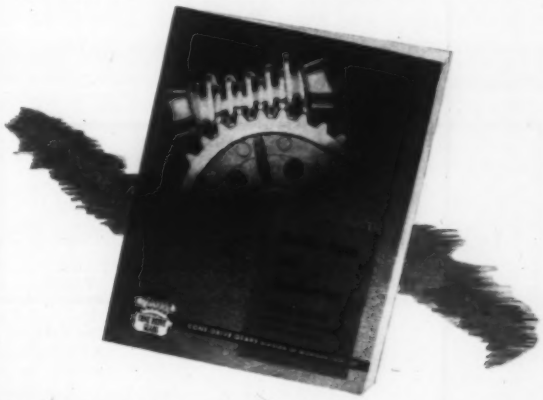
You can calculate the bearing loads and sizes needed for the worm and gear shafts.

You can check the worm root stress and gear tooth stress.

Efficiency is charted against helix angle with modifications for required speed so you can quickly determine efficiency.

One quick look at the drawing above will convince even the uninitiated that no other worm gearset has so many teeth in contact. No other worm gearset is so simple to design and rate. No other worm gearset will carry so much load in so little space with so little weight.

Now, Bulletin 200 provides complete design and application data on space-saving double-enveloping worm gearing. Ask for it without obligation.



CONE-DRIVE GEARS DIVISION MICHIGAN TOOL COMPANY

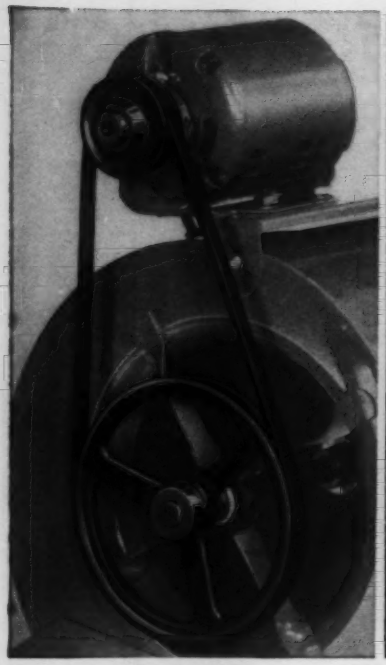
7171 E. McNichols Road • Detroit 12, Michigan • Telephone: TWinbrook 1-3111

DOUBLE-ENVELOPING WORM GEARSETS

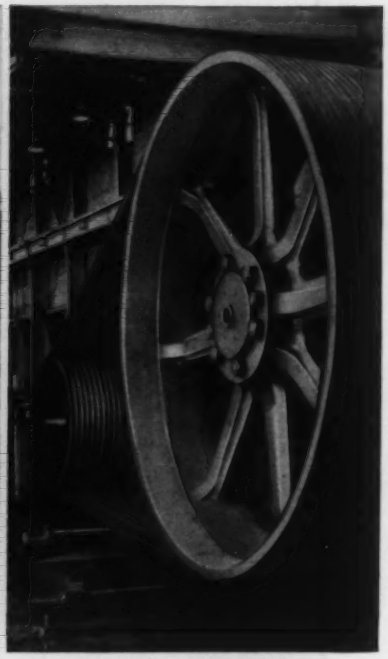
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS

DOUBLE REDUCTION WORM GEAR SPEED REDUCERS

DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS



FHP V-DRIVES

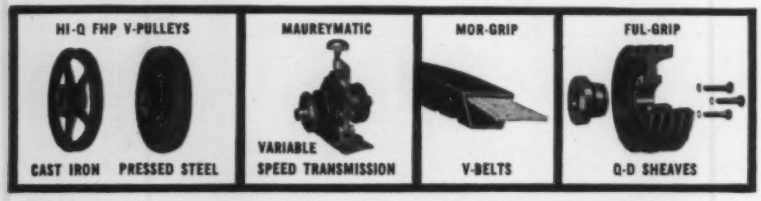


HEAVY DUTY MULTI V-DRIVES

Since 1917...

American industry has approved maurey quality

41 years since 1917 have taught us at Maurey that American industry appreciates quality. Today's complete Maurey V-Drive line reflects that lesson. The Maurey Hi-Q V-Pulley ranks No. 1 in the FHP V-Pulley field on true-running, belt-saving performance and wide industrial use. In the field of heavy duty drives, Maurey Ful-Grip Q-D Sheaves and standard Multi-V sheaves are recognized quality leaders. Every Maurey Mor-Grip V-Belt, and V-Drive accessory is engineered and quality-built to deliver the finest, most dependable V-drive performance your dollar can buy. The free literature listed below will help you to better V-drive performance. Write for it.



For V-Drive Users, Designers

- V-Drive Engineering Manual
- FHP V-Drive Catalog No. F-10
- V-Belt Catalog No. V-55
- Multiple V-Drive Catalog No. MVD-56
- Maureymatic Variable Speed Transmission Catalog No. MM-56

Write for free copies.

maurey

MANUFACTURING CORPORATION, 2803-27 S. WABASH AVE., CHICAGO 16, ILL.

New Parts

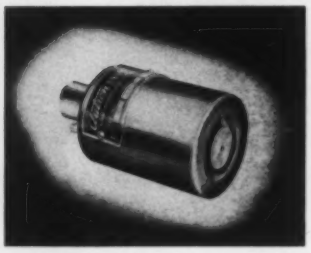
or fracture wood, and can be driven close to an edge or corner. Screw is suitable for use with automatic hopper-fed power screw drivers, conventional electric, and pneumatic screw drivers. Variety of head styles is available in a wide range of screw sizes and lengths. A finishing or other type of washer can be preassembled to the screw to eliminate hand assembly. **Shakeproof Div.,** Illinois Tool Works, St. Charles Road, Elgin, Ill. J

Circle 670 on Page 19

Proximity Detector

is designed for sorting and counting

Model 6120 proximity detector is a highly sensitive unit which responds to the presence of all metallic and most nonmetallic materials. It detects a change of position of metallic objects passing within a half-inch of its face. When used in conjunction with a



controller, unit can also be used for limiting, warning, process control, and gaging. Response rate of 400 parts per min gives unit a high-speed capacity. Output is nominally 5 v dc across a 5 megohm load. Unit is available for industrial applications where use of a light beam and physical contact with the material are not feasible. **Autron Engineering Inc.,** 1254 W. 6th St., Los Angeles 17, Calif. L

Circle 671 on Page 19

Check Valve

has nylon body

No. 15 insertable-union check valve, available in 1½-in. size, has a body of 101-grade nylon. Valve, which installs easily in existing piping, has low pressure drop. Resilient nylon fins seat tightly despite irregularities or angle dif-

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DIVISION OF CHANNING CORPORATION
30th & HUNTING PARK AVENUE
PHILADELPHIA 40, PENNSYLVANIA

Circle 513 on Page 19

NICE®

NICE BALL BEARING COMPANY
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VISIT NICE BOOTH NO. 131, DESIGN ENGINEERING SHOW, CHICAGO, APRIL 14th-17th

Econ-O-"Miser"

Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

* Pat. Pending

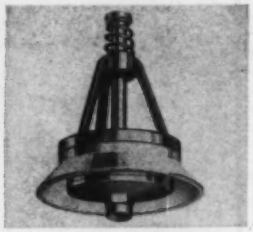
Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

Circle 514 on Page 19

New Parts



ferences of union faces. Valve body acts as a gasket between face of the union. Model 15-S, also available, has a 40-mesh brass screen strainer. **Jordan Industrial Sales Div.**, OPW Corp., 6013 Wiehe Rd., Cincinnati 13, Ohio. G

Circle 672 on Page 19

Hot-Melt Adhesive

has application in small parts assembly

Ray-Bond R-84001 provides instant grab when applied to glass, etched Teflon, Mylar, polystyrene, polyethylene, and other materials. Material can be used in assembly line operations for holding parts in place until they can be permanently fastened. It can also be used as a permanent binder when temperatures are below 150 F. Composed entirely of solids, adhesive is furnished in a semibrittle state. It is liquefied by heating to 250 F, and is applied in the fluid state to one of the parts to be assembled. The other part is pressed into contact and the two held together until adhesive cools. Strength of bond increases as adhesive cools to room temperature. Adhesives Dept., **Raybestos-Manhattan Inc.**, Bridgeport 2, Conn. B

Circle 673 on Page 19

S-Section Sheave

has range of 5.5 to 120 in.

S-section Vari-Pitch sheave permits wide speed changes and in-

...more torque per pound and per dollar!

Merkle-Korff Geared Motors

In geared motors it's torque that counts! Highest torque output at lowest cost to you is achieved by Merkle-Korff's combination of two operating principles:

1. Maximum gear reducer efficiency, the result of 45 year's design experience. Precision hobbed gearing, heat treated. No molded or stamped gearing. Sealed-in-oil housings.

2. Maximum horsepower output with minimum weight motors, uniquely engineered to produce startling torques equal to or in excess of full load torque.

Application engineering is Cost Reduction Engineering at Merkle-Korff. From our many basic models and thousands of variations, let us engineer an improved geared motor drive for you.

From .4 to 300 inch pounds at 800 to ½ RPM

Many other speeds and torques above and below this range are available.

Write for complete information

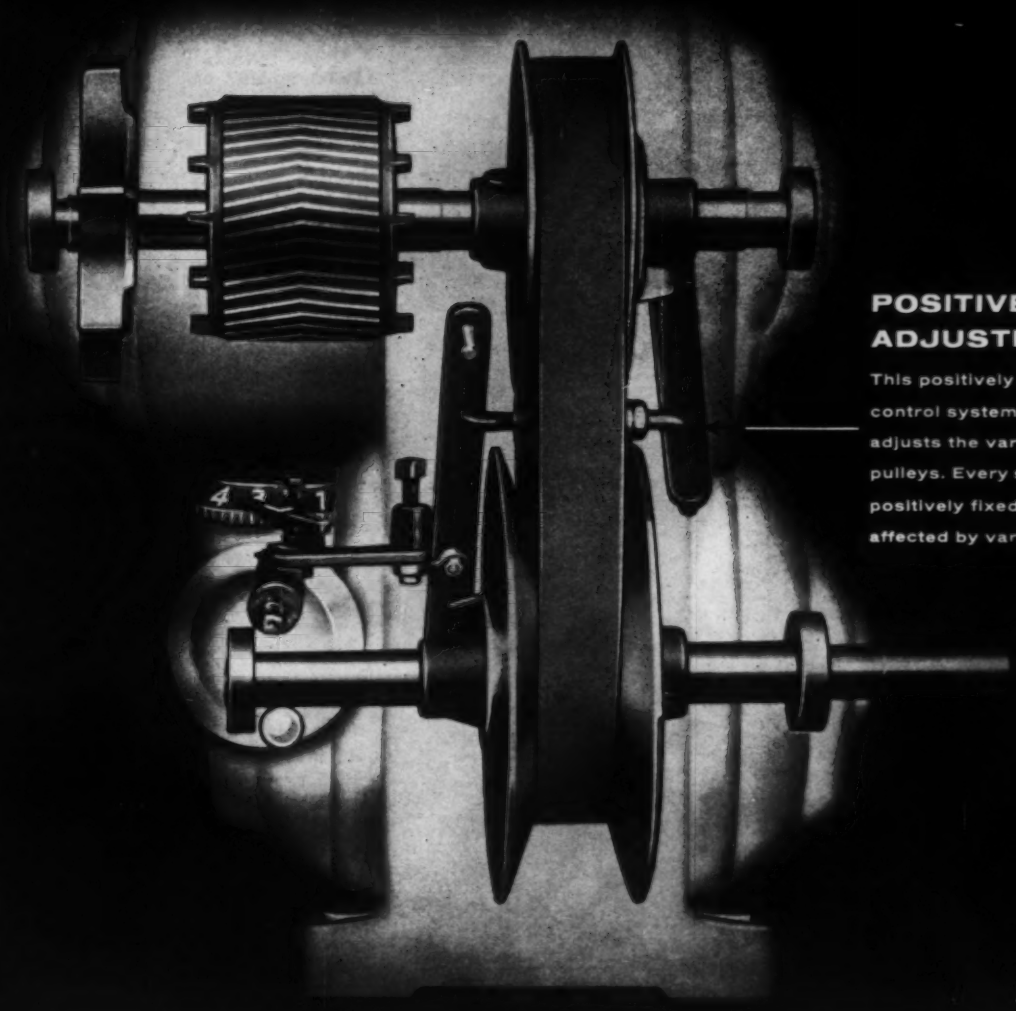
Representatives in principal cities

MERKLE-KORFF GEAR CO.

215 N. MORGAN ST., CHICAGO 7, ILL.

MOnroe 6-1900

Circle 515 on Page 19



POSITIVE PULLEY ADJUSTMENT

This positively linked speed control system reciprocally adjusts the variable pitch pulleys. Every speed setting is positively fixed and is not affected by variations in load.

New Worthington motor drive gives you

ACCURATE SPEED REGARDLESS OF LOAD

Once you set the speed on a Worthington variable speed motor drive, the pulley holds it – maintaining accurate speed control regardless of variations in load.

This unique feature is the result of "positive pulley adjustment." A positively-linked speed control system reciprocally adjusts the variable pitch pulleys. Unlike spring-equipped drives which constantly maintain maximum belt tension to meet occasional peak loads, belt tensions in a Worthington drive never exceed the actual load transmitted. Peak and momentary starting loads are transmitted just as smoothly as they would be with a standard fixed speed V-belt drive.

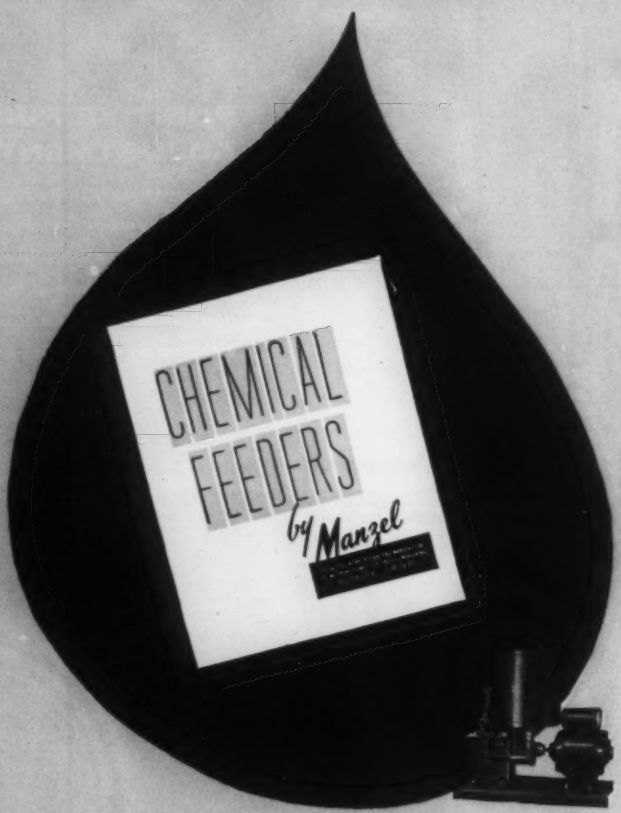
Positive pulley adjustment also results in a compact design with inherently long belt life. The wide-angle design of the belt offers deep side walls for greater contact area. This feature gives you high power capacity with minimum belt pressure. The large diameter pulleys assure smooth, efficient operation with little wear.

The new line is available in speed variations up to 10:1 and horsepower ratings from ½ to 25 hp. You can specify finger tip speed control or one of the many types of remote controls – both automatic and mechanical. For complete information, write for Bulletin 1610-B1. Address Section MV-78, Worthington Corporation, Oil City, Pa.

WORTHINGTON

Circle 516 on Page 19

select the right MANZEL
chemical feeder
from this **new catalog**



WHATEVER YOUR REQUIREMENTS for liquid metering, be sure to get the *exact* unit you need . . . with this new Manzel Chemical Feeder Catalog. It's the most complete, most useful catalog on metering pumps ever published. Gives detailed engineering data, with recommendations for handling *specific* chemicals, acids and other liquids. Thirty-six pages of valuable information designed to help you select the correct proportioning pump.

WRITE FOR YOUR FREE COPY and take the guesswork out of metering pump selection.

Manzel

A UNIT OF HOUDAILLE INDUSTRIES, INC.

276 Babcock Street • Buffalo 10, New York

Specialists in metering pumps and lubricators since 1898

New Parts

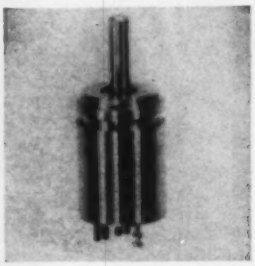
creased power-transmitting capacity. The single-groove sheave has a range of 5.5 to 120 in. **Allis-Chalmers Mfg. Co.**, P. O. Box 512, Milwaukee 1, Wis. K

Circle 674 on Page 19

Potentiometer

has temperature range from −55 to 150 C

New ½-in., high-temperature, single-turn potentiometer is designated Series 5000. The stainless-steel unit has a temperature range of −55 to 150 C. Power rating



above 5000 ohms is 2.5 w at 60 C, derating to 1 w at 150 C. Standard resistance range is 500 to 70,000 ohms with linearity tolerance of ±0.5 per cent. Three models are available in linear and nonlinear types. **Helipot Corp.**, Div., Beckman Instruments Inc., Newport Beach, Calif. L

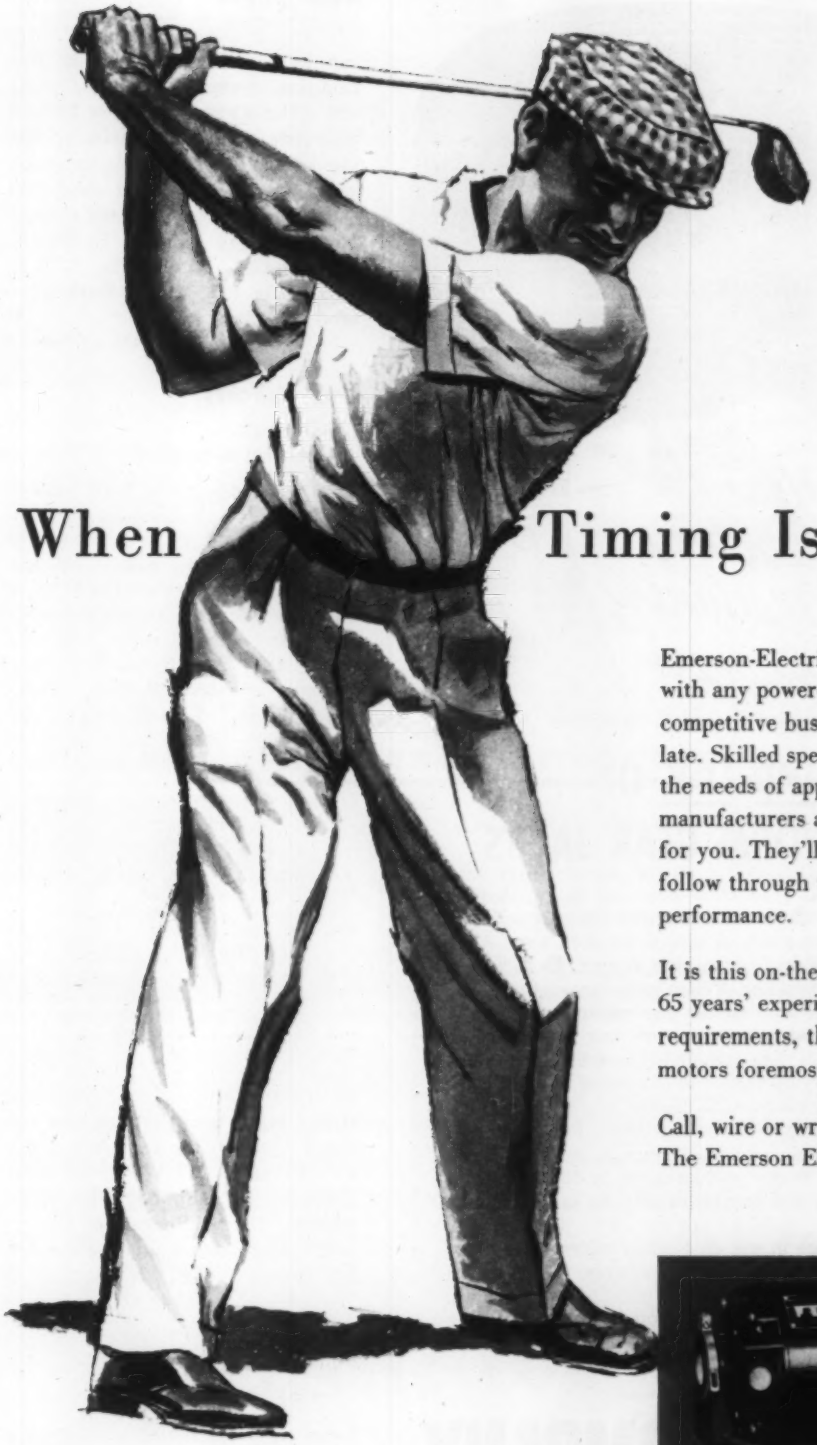
Circle 675 on Page 19

Strainer

for fluid-power transmission systems

Tell-Tale strainer is a suction-line strainer for use in all fluid-power transmission systems. Visual and electrical models are available. Visual model is for use where preventative maintenance is practiced. Electrical model indicates when the strainer is dirty either by turning on a light or disconnecting the starter of the motor driving the pump. Two strainers

Circle 517 on Page 19

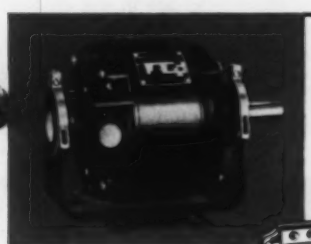


When Timing Is Important

Emerson-Electric is ready to help you *right now* with any power-drive problem. In your highly competitive business, tomorrow can be too late. Skilled specialists who know motors and the needs of appliance and equipment manufacturers are always ready to go to work for you. They'll start with your design ideas—follow through to production and tested performance.

It is this on-the-spot service, plus more than 65 years' experience meeting motor-drive requirements, that have made Emerson-Electric motors foremost in appliance applications.

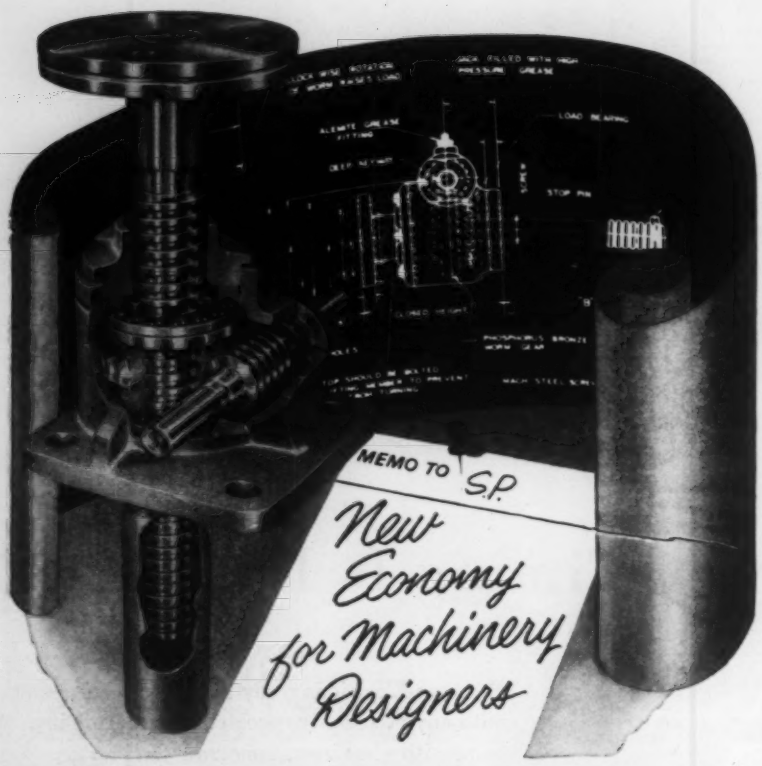
Call, wire or write Dept. M95 today.
The Emerson Electric Mfg. Co., St. Louis 21, Mo.



Every Emerson-Electric motor is custom-engineered to meet your exact requirements.

EMERSON-ELECTRIC

of St. Louis *Since 1890*



NOW, A STANDARD LINE OF DUFF-NORTON WORM GEAR JACKS

The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

COFFING HOISTS
Ratchet Lever
Spur Gear, Electric

New Parts

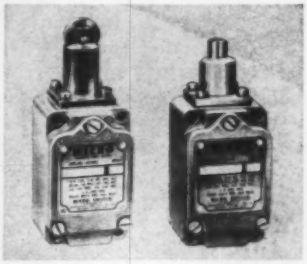
can be installed in complex suction-line systems, for alternating use. Units are obtainable for use with oils, synthetic fluids, or water-soluble fluids. Single units are rated for 20 gpm, and dual unit for 40 gpm. Strainer can usually be applied to existing hydraulic-power units. **Rosaen Co.**, 1776 E. Nine Mile Rd., Hazel Park (Detroit), Mich. H

Circle 676 on Page 19

Limit Switches

have high electrical capacities

Two new two-circuit limit switches include a roller-plunger-actuated type and a push or in-line plunger-actuated unit. Roller-plunger switch, designated 5LSI, is effective for cam or slide operations, and can be rotated 90 deg from the switch cover plate. Plunger-actuated switch, designated 2LSI, offers a full ¼ in. overtravel. Both are compact, have high electrical capacities, and



are completely sealed. Electrical rating is: 10 amp, 120, 240, or 480 v ac; ½ hp, 12 v ac; 1 hp, 240 v ac; 0.8 amp, 115 v dc; 0.4 amp, 230 v dc; 0.1 amp, 550 v dc. **Micro Switch,** Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. K

Circle 677 on Page 19

Double Pumps

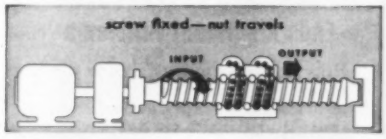
for hydraulic oil service

Series QGH-H double pumps for hydraulic oil service consists of two commonly mounted 2000-psi cartridges. Capacities of each cartridge section range from 3 to 18 gpm or any combination of these volumes. Speeds are 1200 and 1800 rpm, and pressures are up to 2000 psi. Four-bearing, split-

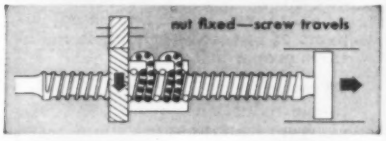
Here's your new ANSWER

PHOTOGRAPHED ACTUAL SIZE
BALL CIRCLE DIAMETER: 3/16 inch.

WORLD'S SMALLEST ball/bearing SCREW SOLVES CRITICAL MINIATURE POSITIONING/CONTROL PROBLEMS



NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque than acme screws.



SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with unprecedented efficiency.

An unprecedented achievement in minimum size and weight—maximum efficiency, dependability and service life for ultra-precise controls.

It's another first from Saginaw—and the possibilities it opens up for improved electrical and electronic controls are limited only by your imagination! Radar tuners, missile and rocket guidance and telemetering systems, automatic switchgear, electronic machinery controls are just a few of the applications where this new miniature Saginaw b/b Screw will solve critical positioning/control problems. *It's so compact and light,* you can save substantially on space and weight. *It's so efficient,* (over 90%) you can use much smaller motors and gear boxes. *It's so precise,* you can position components within .00005 inch per inch of travel. *It's so dependable,* you can rely on remarkably long service life even in adverse environments.

You will find our 1958 Engineering Data Book extremely helpful in planning applications, or experienced Saginaw engineers will gladly make specific recommendations without obligation. Just phone, write or mail the handy coupon.

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ball/bearing Screw

SAGINAW STEERING GEAR DIVISION OF GENERAL MOTORS • SAGINAW, MICHIGAN
WORLD'S LARGEST PRODUCER OF BALL BEARING SCREWS AND SPLINES

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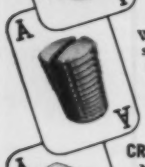
Full House!

...a setko self-locking set screw for every problem!

... And, *every* Setko Self-Locking set screw is an *ace* performer! Each one depends on a specific design principle to lock fast.

They provide positive locking action ... speed assembly and cut costs by utilizing standard driving techniques ... don't require special tapping. All are available in regular points, patented Nu-Cup point, and standard sizes and threads. With the Setko System, they can be hopper-fed in sizes as small as #2 (.086" x 1/8").

ZIP-GRIP® SET SCREWS
Exclusive Contra-Thrust action locks at any point. Solves problems of loosening due to wear, clearance in the thread, or vibration. Can be re-used.



OFFSET SET SCREWS
When driven, two offset edges in threaded portion exert powerful spring pressure. Not affected by extreme variations in tapped holes.

CREST-LOK SET SCREWS
New, original design doesn't require precise tapping. Can be re-used repeatedly. Amount of lock can be altered by changing tap drill size.

POINT-LOK SET SCREWS
This design ends top-screw loosening on two-screw applications. Lower screw can be locked with Point-Lok without disturbing original setting. Can be re-used.

SPRED-LOK® SET SCREWS
This design is for soft metal applications. Top is "spread" slightly to take up "flow" of soft metal. Can be re-used.

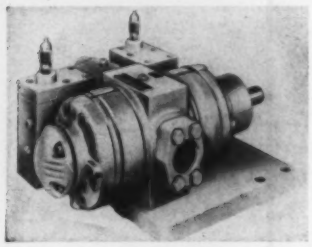
Other Setko Self-Locking set screws that solve specific problems include Flush-Lok, Wedge, Truncated and Jam-Lok. A complete description of Setko set screws including Nu-Cup and Self-Tapping, and the Setko System for hopper-feeding headless set screws is contained in Catalog 21. Write today for your free copy

Set Screw & Mfg. Co.
28 Main Street, Bartlett, Ill.

1583

Circle 521 on Page 19

New Parts



shaft construction permits quick change of capacities. Pumps are available with either base or flange mounting, with or without panel-mounted valve combinations. **Gerotor May Corp.**, Owing Mills, Md. C

Circle 678 on Page 19

Corrosion-Resistant Pipe

of integrally bonded clad steel

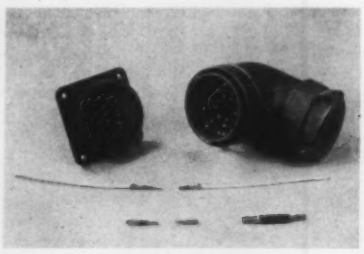
Small-diameter pipe has an inside surface of solid stainless steel, permanently bonded to a heavier outer layer of carbon steel. Available in diameters down to 4 in., the pipe provides the corrosion-resistance of solid stainless pipe. Applications include use in the chemical, petroleum, petrochemical, and nuclear industries. **Lukens Steel Co.**, 1957 Lukens Bldg., Coatesville, Pa. C

Circle 679 on Page 19

Plug-Receptacle Connector

for electronic computers

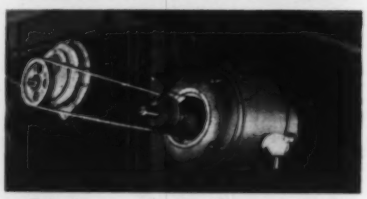
Solderless An-type plug-and-receptacle connector provides speed and flexibility in connecting computer modules. Wire ends are crimped into pins and sockets, which are snap-locked into mating units of connector. Both pins and sockets can be inserted in the same plug and receptacle of the connector. Sockets can also be inserted in the receptacle and pins in the plug unit. Pins and sockets can be inserted in as many of the connector



NEW!

Lovejoy

Shaft Mounted GEAR REDUCER



- **Eliminates Motor Bases...Rails ...Supporting Structures... Shaft Couplings**
- **Ends Alignment Problems**

Provides a compact, space saving power transmission unit for countless industrial applications. Easily installed direct to driven shaft. Mounts vertically or at any angle. Affords infinite speed ratios through use of variable speed pulleys or by changing sheaves, sprockets or prime mover speed. Simple adjustment of rod and turnbuckle maintains proper belt tension.

18 models:
Single reduction types ... 98% efficient ... 4.5:1 nominal speed ratio.

Double reduction types ... 96% efficient ... 14.7:1 nominal speed ratio.

Horsepowers: fractional to 120.

Output speeds: 8 to 425 rpm.

Hollow shaft sizes: 1 7/16" to 5 15/16" (maximum) ... bushings available to accommodate smaller shafts.

Roller backstop: available where protection against reversal of direction is required.

Torque reaction bracket: furnished for units with platform-mounted or reversing drives.

Request Catalog R-58 for complete information. Give application data for specific recommendation.

LOVEJOY FLEXIBLE COUPLING CO.
4818 W. LAKE ST. • CHICAGO 44, ILL.

Circle 522 on Page 19

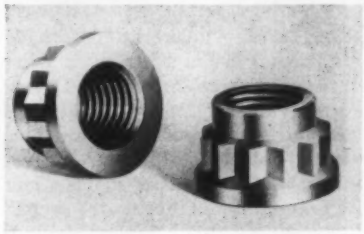
positions as desired, and can be removed individually for circuit changes or field servicing. **Burndy Corp.**, Norwalk, Conn. B

Circle 680 on Page 19

Wrenching Lock Nut

is lightweight, 12-point unit

Lightweight, high-strength, 12-point external wrenching lock nut for critical airframe fastening applications is a self-locking unit rated at 180,000 psi minimum tensile strength. It is available in diameters from ¼ through ½ in., National Fine series. Lock is al-



loy steel, either plain or cadmium-plated, and is rated for temperatures to 550 F. Solid locking collar is squeezed inward in three places to provide vibrationproof locking action once the bolt is threaded into the nut. **Standard Pressed Steel Co.**, Box 102, Jenkintown, Pa. C

Circle 681 on Page 19

Electronic Tachometer

is unaffected by severe vibration

ET-1 electronic tachometer measures rotational speeds from 0.1 to 10,000 rpm with accuracy to within 1 per cent. Manual selector changes a specific full-scale range electronically. Radial lines scribed on a rotary disc interrupt a light beam in the transducer, which has only one moving part, producing 360 pulses per revolution. Electronic circuit detects these pulses for indication on a large, easily read meter. Tachometer is unaffected by temperature changes, line voltage changes or frequency variations, and resists severe vibration. Applications include use with all rotating and moving equipment, such as conveyors, mo-

Illustrated is a Lucas Horizontal Boring Machine equipped with a Gusher Coolant Pump tank unit.

with Ruthman GUSHER Coolant Pumps

Your Gusher Coolant Pumps are precision built of the best materials, electronically balanced for efficient operation. You get split-second coolant flow, there is no priming needed. Pre-lubricated ball-bearings, no pump packing, no foot or relief valves necessary, cut maintenance to a minimum. Write for catalog today.

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• MOLTEN METAL PUMPS

1811 Reading Road Cincinnati, Ohio

HELI-COIL®

SCREW-LOCK* INSERTS

hold fasteners tight!

Cutaway showing *Heli-Coil* Screw-LOCK Insert in flange seat of Chicago Pneumatic Impact Wrench.

Designed for greater speed, safety and economy, Chicago Pneumatic Impact Wrenches exert tremendous tightening and loosening power, resist severe shock loads and rough on-the-job use.

A key feature of their construction is the use of *Heli-Coil* Screw-LOCK Inserts which lock screws within the tapped holes at vital connections. No heavy, protruding lock-nuts are required, no lock-washers. No costly, time consuming lock-wiring. And security? *Heli-Coil* Screw-LOCK Inserts meet Government specs for locking torque and vibration. The wrench is made of aluminum alloy for lightness and ease of handling, but thread stripping in this light metal is eliminated by the stainless steel Screw-LOCK Inserts.

HELI-COIL Screw-LOCK Inserts

- positively lock screws against loosening under impact and vibration
- prevent thread wear, stripping, corrosion, galling, seizing
- eliminate need for lock-nuts, lock-wiring, other supplementary locking devices
- offer high re-useability on repeated disassembly and reassembly

Screw-LOCK Inserts are available in a complete range of sizes, including the new miniature 4-40. For more information on how to make your product lighter, tighter, more compact or less costly, write

HELI-COIL CORPORATION
Shelter Rock Lane, Danbury, Connecticut
A DIVISION OF TOPP INDUSTRIES, INC.

*Pat. Applied For

HELI-COIL CORPORATION
501 Shelter Rock Lane, Danbury, Conn.

☐ Send me complete design data on *Heli-Coil* Screw-LOCK Inserts.

NAME _____ TITLE _____

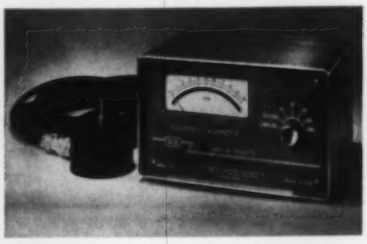
FIRM _____

ADDRESS _____

CITY _____ ZONE ____ STATE _____ 4759

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

New Parts



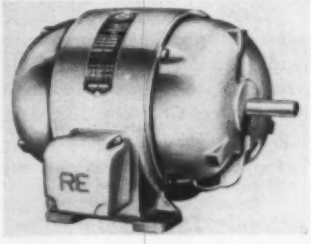
tors, pumps, machine tools, and mills. **Southwestern Industrial Electronics Co.**, P. O. Box 13058, Houston 19, Tex. I

Circle 682 on Page 19

Electric Motors

in ½ through 40 horsepower ratings

New line of electric motors for industrial use is available in frame sizes 182 through 326U and horsepower ratings of ½ through 40. Either drip-proof or totally enclosed fan-cooled types are offered. The NEMA rerated motors have all-aluminum frames to provide lighter weight. Expandable design permits many power-package adaptations with fluid couplings,



gear reducers, and magnetic brakes. **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif. L

Circle 683 on Page 19

Hydraulic Pump

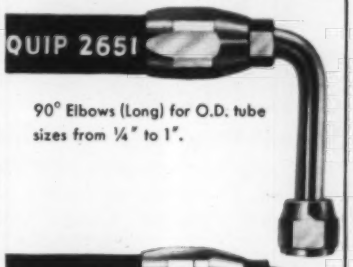
operates continuously at 4000 psi

Variable-displacement, piston-type hydraulic pump permits operation in hydraulic fluids and engine lubricating oils with particle sizes up to 40 mu. Unit operates continuously at 4000 psi. Axial pistons reciprocate in a revolving cylinder block supported by a trunnion-mounted yoke. Piston stroke is varied from zero to maximum by changing the angle of the yoke.

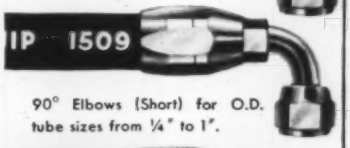
Simplify Fluid Line Installation in Confined Spaces with Aeroquip Elbow Hose Fittings and Assemblies

ELBOW FITTINGS AVAILABLE

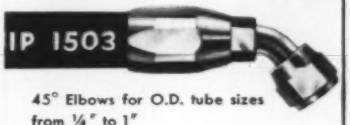
Swivel Nut Ends—S.A.E & J.I.C.



90° Elbows (Long) for O.D. tube sizes from ¼" to 1".

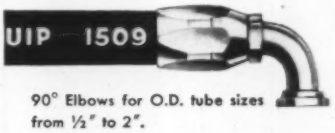


90° Elbows (Short) for O.D. tube sizes from ¼" to 1".

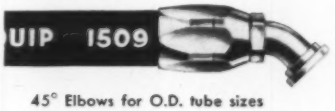


45° Elbows for O.D. tube sizes from ¼" to 1"

Split Flange Ends—"O" Ring Shoulder



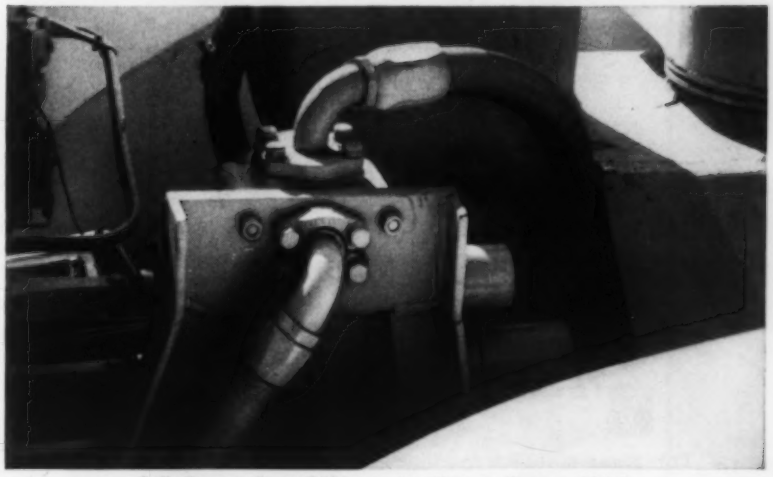
90° Elbows for O.D. tube sizes from ½" to 2".



45° Elbows for O.D. tube sizes from ½" to 2".

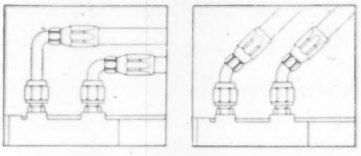
Standard 4-Hole Flange Ends

90° Elbows for 2½" & 3" O.D. pipe.



Split flange elbow fittings connecting medium and high pressure hydraulic lines on construction equipment.

Where fluid line routing is complex and space is limited, hose assemblies with elbow fittings can be especially helpful to good design and simple installation. Elbow fittings provide fewer parts, adapters and joints, shorten assembly time,



and permit compact hose bends and contours without placing stress on the hose itself.

Aeroquip offers elbow fittings and hose for a wide range of industrial applications, in end connections to fit S.A.E. and J.I.C. swivel nut, standard flange and split flange systems. And, every Aeroquip Elbow Fitting is completely detachable from the hose. This permits reuse of the fitting again and again when making replacement hose lines, with substantial savings in maintenance time and money.

Full information on Aeroquip Reusable Elbow Fittings and Hose is available to product designers. Fill in and mail the coupon below for the engineering bulletins you want plus a handy guide for routing and installation of Aeroquip Hose Assemblies. Complete engineering assistance is available to manufacturers.

Aeroquip Corporation
Jackson, Michigan

Please send me a copy of "Guide for Routing and Installation of Aeroquip Flexible Hose Assemblies" plus the following engineering bulletins:

MD-1

☐ IEB-3 on Split Flange Elbow Fittings

☐ IEB-27 on Swivel Nut Elbow Fittings

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE____ STATE_____

SEE OUR CATALOG PAGES IN SWEET'S PRODUCT DESIGN FILE, SECTION 6d.

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA

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Kane and Roach Machine for straightening bar stock up to 1¾" square or hex, 2⅜" round, 4" x ½" flat-on-edge, 6" x 1" flat-on-flat at 100-300 fpm.

AJAX

DIHEDRAL COUPLINGS

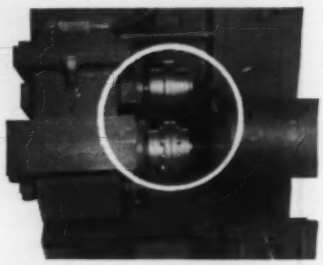
PERMIT VARYING ANGULARITY IN THE DRIVE MEMBERS OF *STRAIGHTENING MACHINES

▶ This Kane & Roach machine straightens cold or hot rolled steel and non-ferrous bar stock and AJAX DIHEDRAL COUPLINGS "straighten" angularity in the drive members.

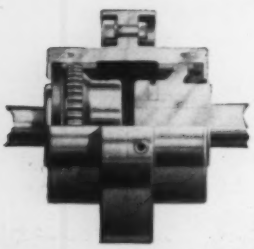
The ability of AJAX Dihedral Couplings to handle up to 12° misalignment make it possible to adjust the Horizontal and Vertical straightening units to align passes of Multipass rolls, thereby reducing roll change-over time. Production speed ranges from 100 to 300 feet per minute when straightening 65,000 pound yield material in both horizontal and vertical planes.

AJAX Dihedral Couplings are used in the primary drive and in the drive to the Vertical unit to obtain "floating shaft" action and reduce wear on the bearings of driving and driven components. An AJAX Dihedral Coupling is also used in drive to the line shaft of the Horizontal unit to assure minimum bearing wear. Adoption of AJAX Dihedral Couplings by Kane & Roach is another example of how manufacturers of quality machines are safe-guarding performance and reducing maintenance cost. AJAX Engineers will welcome an opportunity to discuss the design possibilities resulting from AJAX Dihedral Coupling Performance.

*KANE & ROACH, INC.



AJAX Dihedral Coupling obtains floating shaft action to permit varying of alignment of roll passes.

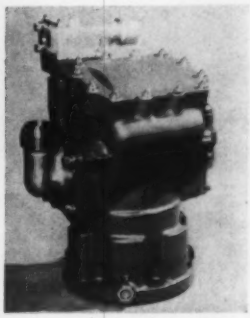


AJAX Dihedral Couplings protect bearings from wear due to adjustment of vertical and horizontal unit.

AJAX FLEXIBLE COUPLING CO. INC.
WESTFIELD, NEW YORK

Circle 526 on Page 19

New Parts



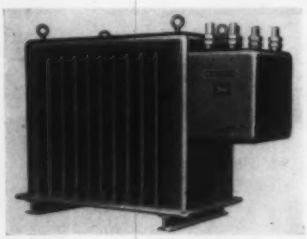
Cylinder block, yoke and valve plate, and bearings have been redesigned to insure reliability at the higher pressure. **Vickers Inc.**, Detroit, Mich. H

Circle 684 on Page 19

Power Supplies

in seven capacities from 50 to 500 kw

Oil-filled silicon-rectifier power supplies are available in seven capacities from 50 to 500 kw. Input voltage is up to 4160 v, and output to 250 v dc. With approximately 95 per cent efficiency, voltage regulation is 5 per cent or better. Rectifiers, measuring 90 x 72 x 44 in., are cased in a sheet-steel cabinet. They are oil and water-



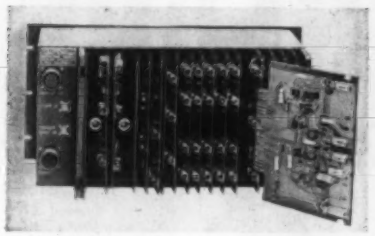
tight, and have sealed silicon junctions. **Walker Div.**, Norma-Hoffman Bearings Corp., Stamford, Conn. B

Circle 685 on Page 19

Encoder

is all-electronic unit

Type 525 encoder provides precise and dependable conversion of analog input data to digital output voltages. An all-electronic unit, it has high accuracy and resolution. Dependable operation is maintained over a wide range of environmental conditions. Encoder makes possible the use of noisefree



digital transmission and computing techniques to a high degree of accuracy. **Avion Div.**, ACF Industries Inc., 800 N. Pitt St., Alexandria, Va. C

Circle 686 on Page 19

Air-Duct Joints

for temperatures to 550 F

Self-aligning air-duct joints for aircraft, missile, and other industries, have long cycle life with 10-deg self-aligning and 360-deg rotation capabilities. They are available in bore size of 5 in. with operating pressures of 110 psi and temperatures to 550 F. Other bore

sizes are furnished on request. **Southwest Products Co.**, 1705 S. Mountain Ave., Monrovia, Calif. L

Circle 687 on Page 19

Plastic Laminates

have high resistance to heat and flame

Dilecto flame-retardant plastic laminates comprise nine different grades of varying characteristics for a wide range of industrial applications. They combine excellent flame-retardant properties with high strength and good electrical qualities. Laminates contain chemical additives that dampen and extinguish flames started by electric arc or other sources. Included in the line are paper-base phenolic resin laminates, glass-mat polyester resin laminates, and glass-

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FROM A.R.
Maybe we need another source for chain. How about UNION?
You couldn't do better. And here's why. We make all types of steel drive and conveying chain plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.
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The Union Chain And Manufacturing Company
SANDUSKY, OHIO

Circle 527 on Page 19

What's your need for heat?

Whatever your heating job may be, you'll find the efficient, economical answer in . . .

CHROMALOX Electric Heaters

. . . for heating platens, dies, molds, metal parts . . . for heating liquids, air, gases . . . for curing, drying, baking . . . for comfort heating in offices and factories . . . for special applications . . . in fact for any application requiring fast, low-cost, controlled heat up to 1100°F.

IMMEDIATE DELIVERY

from the world's largest factory stock of industrial electric heaters . . . over 15,000 types, sizes and ratings.

Let the Chromalox Sales-Engineering staff solve your heating problems . . . electrically.

Write for your copy of Catalog 50

Contains helpful information on design uses, and prices of Chromalox Electric heaters, elements, thermostats, contactors and switches.

To get some interesting facts about additional applications of electric heat, ask for Booklet F1550—"101 Ways to Apply Electric Heat."

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- ☐ A copy of Catalog 50
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A 4455A

Circle 528 on Page 19

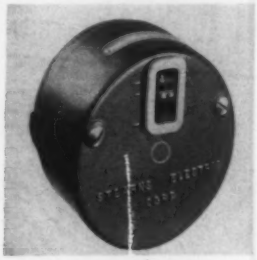
New Parts

base epoxy resin laminates. Materials are available in a wide range of thicknesses, sheet sizes, and tube and rod diameters. **Continental - Diamond Fibre Corp.**, Newark, Del. C

Circle 688 on Page 19

Brake

for operation on all standard voltages

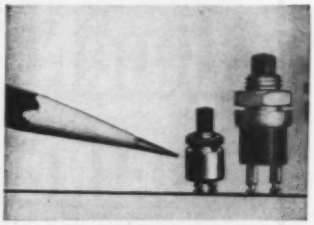


Style HTC 50 Series brake is for use with fractional - horsepower electric motors in frames 56-C and 66-C, and integral motor frames 182 and 184. Brake is available for operation on all standard ac voltages. It includes cast-iron housing and endplate, visual wear indication, and automatic manual release and reset. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis. K

Circle 689 on Page 19

Miniature Switch

pushbutton unit is for use with 1/16-in. panels



Series 39-1 miniature pushbutton switch is a single-pole single-throw, momentary-contact, normally open model, rated 1/10 amp at 115 v ac resistive. Switch is 0.250 in. in diam, and has an overall length of 0.615 in. It is designed for use with 1/16-in. panels and requires a 3/16 in. hole for mounting. **Grayhill Inc.**, 561 Hillgrove Ave., La Grange, Ill. I

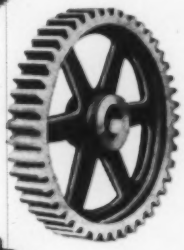
Circle 690 on Page 19

GEARS

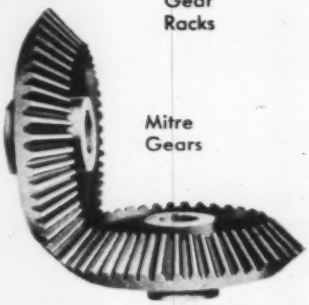
Symbol of QUALITY

Herringbone Gears

Spur Gears



Gear Racks



Mitre Gears

Industrial Gear offers a complete line of the finest cut gears available for the equipment of America. **Plus** — a combination of precision and quality, reasonable costs, and superb service.

INDUSTRIAL GEAR MFG. CO.
4515-39 West Van Buren St.
Chicago 24, Illinois

Circle 529 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Lead and Compass Pointer

is operated electrically

Point Perfect lead and compass pointer is for clutch lead pencils, beam and other compasses. Slight touch of lead against cutters trips an electric switch which operates the unit as long as lead is pressed

among cutters. Unit points lead to a 12-deg included angle. Instrument contains 60-cycle, 28-w, 110-v ac motor. **W. H. Behrens Co.**, 2302 St. Clair St., Racine, Wis. K

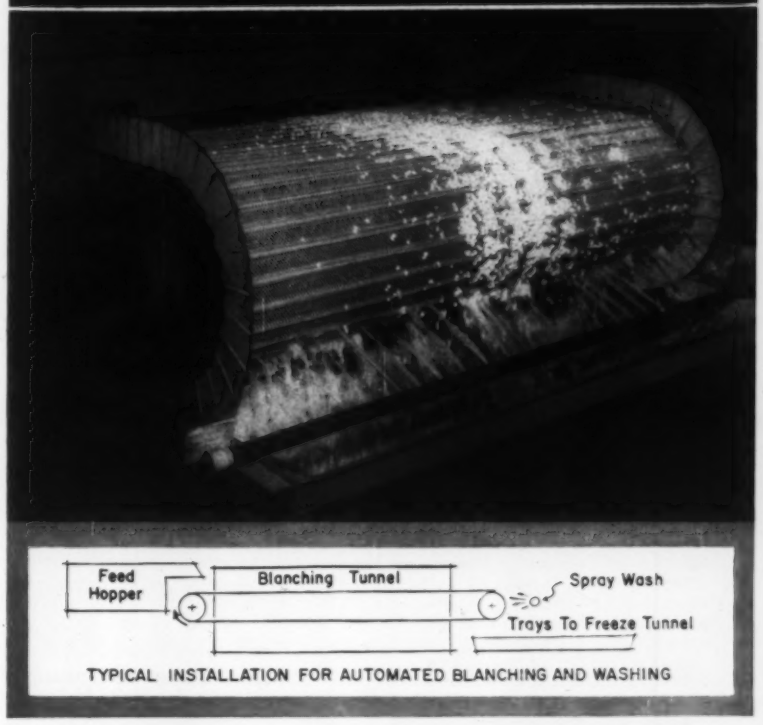
Circle 691 on Page 19

Analog Computer

is 30-amplifier linear unit

Model 3100 analog computer can be operated from a standing or sitting position. Desk-type working surface is directly in front of control panel. All components of the 30-amplifier linear unit are housed in the basic console. Nonlinear equipment can be mounted to one side of console, in modular cabinetry. Digital voltmeters and oscilloscopes are above the control panel. Computer uses a removable problem board which handles 30 amplifiers, 40 potentiometers, 6 function generators, 8 channels of multiplication, and leaves 40 terminals available for other problem boards or nonlinear equipment. Unit contains ten stabilized amplifiers in dual modules. Output voltage is 200 v peak to peak. Maximum current output is in ex-

Cambridge WOVEN WIRE BELTS



TYPICAL INSTALLATION FOR AUTOMATED BLANCHING AND WASHING

Continuous processing on open mesh belts increases product uniformity

Open mesh Cambridge Woven Wire Belts allow liquids, gases, cold or heat to flow freely through the belt and around the product for fast, uniform processing. Metal parts, food, chemical or ceramic products carried through wet, dry, hot or cold processing operations on endless Cambridge belts means increased production and lower operating costs. Here's why:

CONTINUOUSLY MOVING BELT ELIMINATES BATCH PROCESSING; belt to belt flow of materials reduces manual handling, labor costs.

ALL-METAL CONSTRUCTION IS HEATPROOF, RUSTPROOF; takes up to 2100° F. or sub-zero temperatures; resists corrosive attack; has no seams, lacers to wear or break.

SPECIAL SURFACE ATTACHMENTS AVAILABLE; raised edges, cross flights to keep product on belt during inclined movement.

Whether you design machinery for your own use or for resale, your Cambridge FIELD ENGINEER can explain how the many advantages of Cambridge belts make automated processing practical and economical. And, he'll recommend the belt size, mesh or weave— in the metal or alloy—best suited to your operations. Call now. He's listed in the classified phone book under "BELTING, MECHANICAL". Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

The Cambridge Wire Cloth Co.

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OFFICES IN PRINCIPAL INDUSTRIAL CITIES

Circle 530 on Page 19

VALLEY BALL BEARING **MOTORS**

Custom Built . . .
NOT Custom Priced!

AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

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that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY
ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

Circle 532 on Page 19

Design Guide to

Adjustable-Speed Drives

- **ELECTRICAL**
- **MECHANICAL**
- **HYDRAULIC**

$2.00 per copy

Here, in one book—148 pages, with 24 tables, 119 charts and 171 illustrations—is what the designer should know about adjustable speed.

(Remittance or Company Purchase Order must be enclosed with order.)

MACHINE DESIGN READER SERVICE

Penton Building
Cleveland 13, Ohio

Engineering Equipment

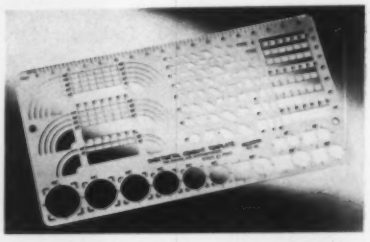
cess of ±10 ma. Consoles can be slaved to each other for further expansion. **Donner Scientific Co.**, 888 Galindo St., Concord, Calif. M

Circle 692 on Page 19

Template

for layout of sheetmetal conduits

No. 48 sheetmetal-conduit template facilitates the layout of sheetmetal conduits for heating and air conditioning. In a scale of ¼ in. to 1 ft, it covers all sizes between 4 and 48-in. cross-sections, either round or square, and permits easy depiction of numerous



special shapes and reducers. Template is 0.030 mathematical-quality plastic, with all cutouts precision milled. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif. L

Circle 693 on Page 19

Self-Sticking Tape

in widths of 1/32, 1/16, and ⅛ in.

Self-sticking special-purpose tape is used to prepare finished art for printed circuit diagrams. It can also be used for preparing mechanical layouts. Long or short curves and radii can be inked in without instruments and corners are neat and square. Tape is dull black, lightly creped for flexibility and backed with a strong, transparent adhesive which holds fast on curves and

radii. Furnished in 360-in. rolls in widths of 1/32, 1/16, and ⅛ in., the tape is accurate to 0.002 in. **American Chart Service Inc.**, 101-103 Dover St., Somerville 44, Mass. B

Circle 694 on Page 19

Folding Machine

has adjustable folding spacing

Rollafold produces neat accordion folds in a long strip or roll of paper, such as the chart from an oscillograph recorder. Fold spacing is continuously adjustable from 6.5 to 12.5 in. at a rate of one fold per sec. **Benson-Lehner Corp.**, 11930 Olympic Blvd., Los Angeles 64, Calif. L

Circle 695 on Page 19

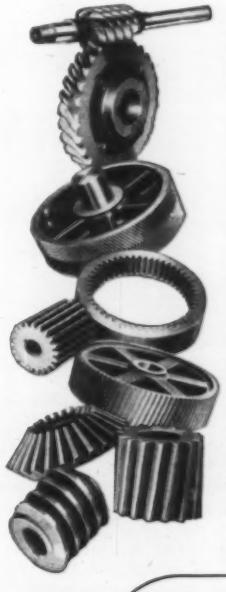
Wave Converter

is sine-to-square plug-in unit

Circuit of this sine-to-square wave converter utilizes the signal from the driving oscillator to provide operating power for the transistor squaring circuit. Operating from 5 to 100,000 cps, unit is capable of 17-v peak-to-peak output when driven from a conventional oscillator. Rise time for the square wave is 0.5 per cent of the period, with symmetry of 50 per cent ±2 per cent. **Mandrel Industrial Instruments**, P. O. Box 13243, Houston 19, Tex. I

Circle 696 on Page 19

This H&S Gear Catalog



gives you complete information for fast, easy gear selection.

In Horsburgh & Scott's new Gear Catalog No. 57 you get *all* the information necessary to design and order the gearing offering greatest efficiency and operating economy for your industrial applications.

Contains Useful New Features:

- Gear Material Selection Guide
- Heat Treating Information and Recommendations
- AGMA Class 1 Horsepower Rating Formulas and Tables
- Shaft Size Formulas
- Maximum Bores for Pinions
- Revised Rules for Ordering
- Gear Cutting Facilities at Horsburgh & Scott

You'll find these and many more informative features in this new 112 page catalog. Send for your *free* copy of H & S Gear Catalog No. 57 today. Please write on your company letterhead.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
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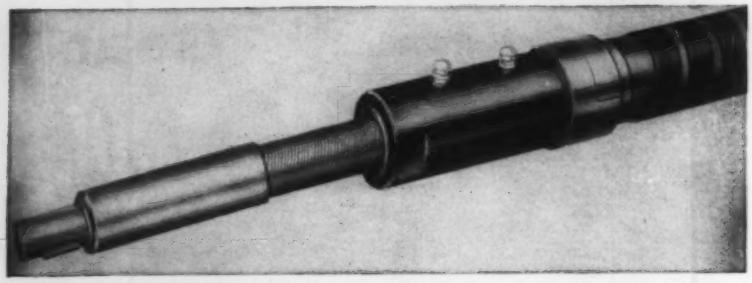
(Advertisement)

HOW TO SELECT FLEXIBLE SHAFTING FOR POWER DRIVE APPLICATIONS



1¼-inch STOW Power Drive flexible shaft with core assembly pulled out of casing.

For Power Drive applications, the following factors must be considered:

1. Torque (Lb. In.) to be transmitted. (The starting torque should be used in making selections.)

2. Operating Speeds (RPM) — If the maximum speed is higher than the rated speed, torque ratings in the table below do not apply. To find the torque capacity for flexible shafts operating at speeds higher than the rated speeds, multiply the maximum dynamic torque capacity by the rated speed, and then divide by the operating speed. (See example.)

3. Operating Radius—In making the selection from the table below, the radius of the smallest bend in the flexible shaft should be used.

Ratings — The ratings for flexible shafts shown in the table below apply under the following conditions:

1. When the flexible shaft is adequately supported by clamps along its length. (For unsupported shafts, multiply the calculated torque by a safety factor of 1.6—see example below.)

2. When the flexible shaft is operated in the wind-up direction, which tends to tighten the outer layer of wires. (Flexible shafts operated in the unwind direction will transmit only about 60% of the rated torque.)

3. When the flexible shaft is in continuous operation. Note: **the ratings are based on temperature rise. When the operation is intermittent, the ratings in the table may be exceeded. Consult Stow engineers for specific recommendations.**

RATED SPEED R.P.M.	MAXIMUM DYNAMIC TORQUE CAPACITY (LB. IN.) STRAIGHT AND CURVED SHAFTS RADIUS OF CURVATURE IN INCHES									Wgt./ C. Ft.	Core Dia.	Core No. and Type	Shaft Size
	50 to Strgt.	25	20	15	12	10	8	6	5				
4,500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	3.0	.124/.128	2049 MH	13
3,800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	4.5	.148/.152	2081 MH	15
2,900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	7.0	185/.189	5108 MH	19
2,500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0	12.5	.247/.252	8924 MH	25
1,800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0		20.0	.308/.313	8925 MH	31
1,800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8		20.0	.308/.313	8969 T	31
1,800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0	21.0	.324/.329	2034 A	31
1,500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0		28.5	.368/.374	2035 A	38
1,500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0		29.0	.387/.393	8970 MH	40
1,500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0		29.0	.387/.393	8971 T	40
1,150	136.0	110.0	104.0	94.0	80.0	72.0	56.0			50.5	.497/.503	8999 A	50
1,150	148	124	110	92	72	56				53.5	.505/.511	6940 T	50
900	248	200	176	124	84					78.5	.610/.618	6997 T	63
900	220	204	192	180	152	130				80.5	.630/.638	7731 A	63
750	340	224	156	76						117	.747/.753	2056 T	75
600	760	520	420							205	.998/1.004	2057 T	100
440	1,500	720								343	1.298/1.304	2058 T	125

EXAMPLE — How to use the table:

The problem is to transmit ½ H P at 1700 RPM through an unsupported flexible shaft in a 25" radius, estimated starting torque 150% of normal operating torque.

1. Calc. Torque (lb. in.)—

$$\frac{HP \times 63000}{RPM} = \frac{.5 \times 63000}{1700} = 18.5$$

2. Correction factor for starting torque 1.5 x 18.5 = 27.75
3. Correction factor for unsupported shaft 27.75 x 1.6 = 44.4 lb. in.
4. Refer to Table above. Read downward in column under 25" radius until you find a core having a rating of at least 44.4 lb. in. In this case we find that core No. 8970 is rated 54 lb. in. at 1500 RPM. Since the given speed is 1700 RPM, multiply 54 by 1500 and divide by 1700. 54 × 1500 ÷ 1700=47.6 lb. in. (rated torque at 1700 RPM). Therefore, Core No. 8970 is correct.

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Recent Books

Principles of the Properties of Materials. *By Jacob P. Frankel, University of California; 228 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$6.00 postpaid.*

This book emphasizes principles and properties of materials rather than specific materials of a class. It does so on the theory that significance of properties changes slowly and is of more value than knowledge of material which may become obsolete.

Topics include the physicochemical foundations of materials; conductivity, heating, elasticity, plasticity, fracture, and viscosity. Each chapter contains a synopsis of material prior to detailed discussion.

Mechanics of Machinery. *By C. W. Ham, E. J. Crane, and W. L. Rogers; 509 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.50 postpaid.*

This fourth edition is divided into two major parts: Mechanisms, and kinematics and dynamics of machinery. Certain material has been expanded to include new applications of current interest, and symbology and terminology of the American Standards Association have been adapted where applicable.

Topics include continuous, intermittent, and reciprocating machine motions; linkages; flexible connectors; cam layout procedures; toothed gearing; velocities, accelerations, static and inertia forces, balancing, vibrations and critical speeds in shafts; and gyroscopic forces.

Digital Computer Components and Circuits. *By R. K. Richards; 511 pages, 6 by 9 in., clothbound; pub-*

lished by D. Van Nostrand Co. Inc., 120 Alexander St., Princeton, N. J.; available from MACHINE DESIGN, *$10.75 postpaid.*

Basic engineering approaches related to digital techniques have been collected and organized for presentation in this book with the intention of providing a ready source of reference material for practicing engineers. Basic principles of logical functions and mechanized arithmetic are included as aids to explanations of components or circuits.

Major topics include diode switching circuits, vacuum-tube and transistor systems of circuit logic, magnetic-core systems of circuit logic, storage on a magnetic surface, and circuits and tubes for decimal counting.

Technical Report Writing. *By James W. Souther, College of Engineering, University of Washington; 70 pages, 8½ by 11 in., paperbound; published by and available from John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; $2.95 per copy.*

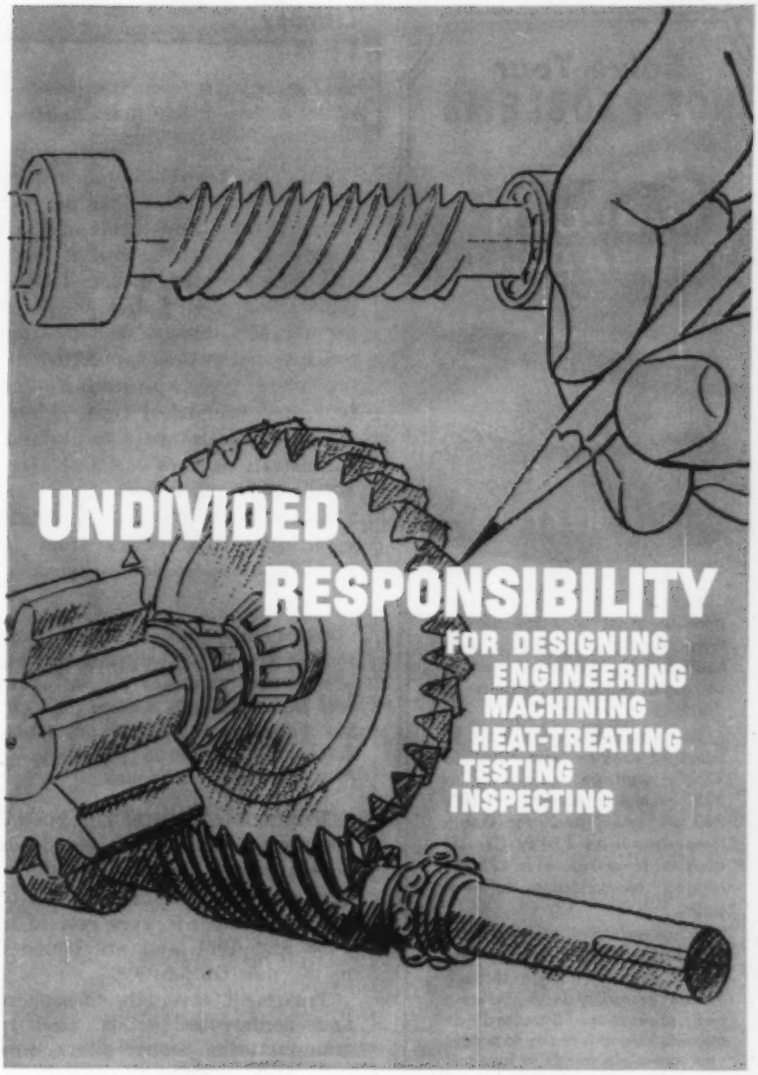
Fundamentals of technical writing are approached from a "design" standpoint. Principles of engineering design, translated to terms of writing, are applied to solutions of reporting problems. Emphasis is on the writing process and methods, and on factors which must be considered in report writing.

The form of the report is related to its use, and illustrations show how report layout becomes a design tool which represents a graphic extension of the organization of its material. This design approach theory is developed throughout each chapter.

A special appendix includes writing check lists, mechanics of copy, reproduction processes, and sample reports.

New Standards

Machine Mounting Specifications for Abrasive Discs and Plate Mounted Wheels, ASA B5.35-1957. *21 pages, 8½ by 11 in., paperbound; published by the American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; available on let-*



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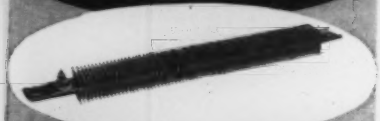

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Library

terhead request from the Grinding Wheel Institute, 2130 Keith Building, Cleveland 15, Ohio.

This new American Standard includes location and size of bolt holes in steel disc wheels and the mounting side of abrasive discs and plate-mounted wheels. Definitions and standard sizes are listed for abrasive discs of the inserted nut, inserted washer, tapped mounting - plate types, projecting - stud type, and cylindrical type. Plate-mounted wheels are also covered.

Illustrations show various classes of discs together with hole patterns for each size, and mounting specifications for discs from 10 to 84-in. diameter are included.

ASTM Standards on Copper and Copper Alloys. *688 pages, 6 by 9 in., paperbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $6.25 per copy, or $7.00 per copy, clothbound.*

This new edition of the special compilation of ASTM standards covers copper and copper alloys, cast and wrought. Thirty-four of the 128 standards were revised in 1956 and 1957 and are included in the new edition.

Treatment covers basic coppers and nonferrous metals used in manufacturing copper alloys, copper, and copper alloy wrought products. Test methods for these materials are included with specifications.

Association Publications

Gray Iron Castings Handbook. *Edited by Charles F. Walton; 620 pages, 6 by 9 in., clothbound; published by and available from Gray Iron Founders' Society Inc., Cleveland, Ohio; $10.00 per copy.*

This first complete handbook on gray and ductile iron castings contains information on how to design, purchase, and use gray, ductile, white, and high-alloy iron castings.

Numerous suggestions for designers are intended to aid translation of a projected design into a finished product. In addition, the manual contains data which de-

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scribe kinds of foundries, casting processes, type of patterns, inspection, and shipping methods. Also included are guides to selection of tool materials and grinding cutting tools for machining, heat treatment methods, and finishing operations.

Certain selected portions of the *Gray Iron Castings Handbook* formed the basis for a co-ordinated group of three articles on fatigue and impact properties of gray and ductile iron which recently appeared in MACHINE DESIGN (Dec. 12, Dec. 26, Jan. 23).

Problems and Practices in Engineering Management. *132 pages, 6 by 9 in., paperbound; available from American Management Association Inc., 1515 Broadway, New York 36, N. Y.; $2.50 per copy to members, $3.75 per copy to nonmembers.*

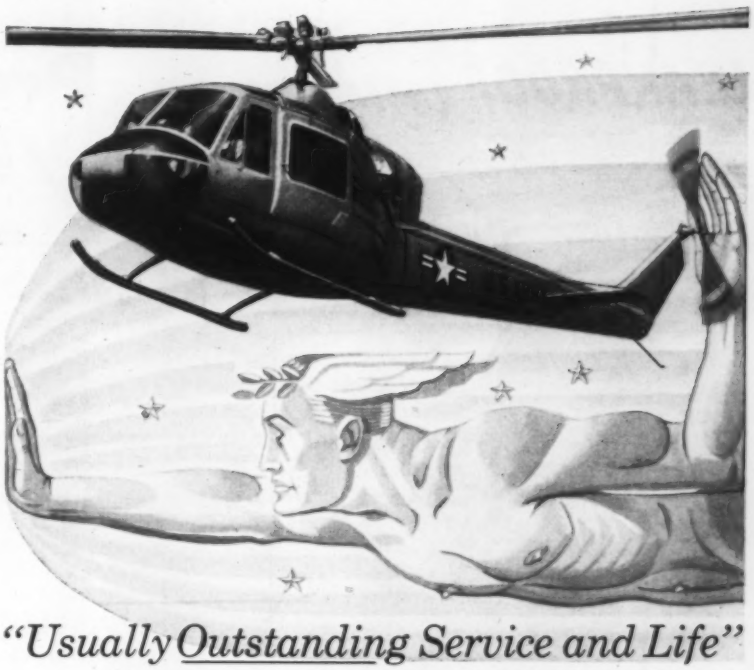
This report is intended to bring management up to date on how best to use its engineering manpower in both technical and managerial capacities. Papers contained in the report were presented originally at a special conference held by the AMA Research and Development Division in New York, April, 1957.

Problems discussed pertain to the engineering shortage, structure and function of an engineering organization, program administration, and effective systems engineering.

Manufacturers' Publications

Welding Data Book. *180 pages, 4 by 5 in., paperbound; available on letterhead request from Technical Information Service, Eutectic Welding Alloys Corp., Flushing 58, N. Y.*

This pocket-size data book features simplified welding procedures for every base metal and covers compositions of 120 welding rods, electrodes, and welding compounds. Information is given for fabrication, maintenance repair and salvage, overlaying for wear and corrosion resistance, and for welding dirty and rusted parts. Special welding applications are also included.



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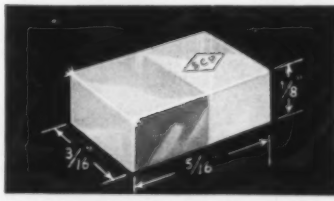

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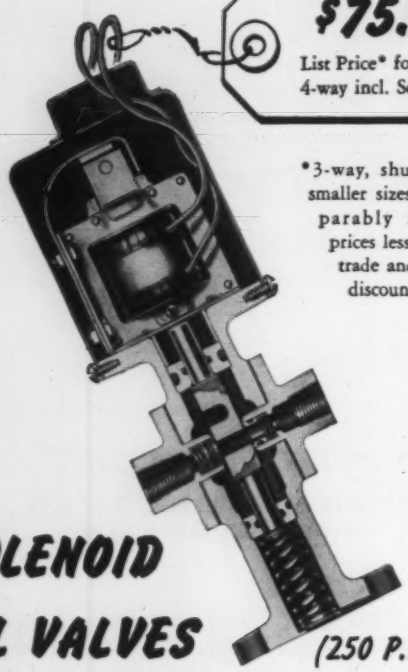

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Automatic door openers	Quick action (high flow capacity)	No spools or poppets obstructing full, round flow passages
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Professional Viewpoints

. . . management's responsibility . . .

To the Editor:

We found the editorial, "Management's Responsibility," in the October 17, 1957 issue of MACHINE DESIGN a very interesting one. We have below quoted and commented on the article in question.

> If you apply for admission to a school of business administration you may be asked such questions as, "What is the purpose of a foundry?" If you answer, "To make castings," you flunk.

It is symptomatic of the shallowness of the typical school of business administration to be unable to conceive of a foundry as having more than one purpose. It is indeed unfortunate that the individual who mentions the distinguishing purpose is flunked.

> A man with good management potential knows, of course, that the purpose of a foundry is to make money.

A man with good management potential also knows that a foundry has other important purposes. In addition to its duty to the stockholders, a foundry has duties to its employees and to the general public. It is hard to see why the "money-making" interest of the stockholders should dictate *the* purpose of a company at the expense of the general public and its employees. A company which produces nothing of worth and reaps huge profits is committing no less than legalized robbery of the consumer public.

> First reaction to such a seemingly hard-boiled attitude might be, "How greedy can you get?" But sober reflection leads to the conclusion that the man is right.

That is, the man who said, "How greedy can you get?" is right!

> Money is the yardstick by which much that we value is measured. And so long as we don't fall in love with the yardstick instead of with what is being measured, we can keep the concept of money in proper perspective.

This paragraph is contradicted in the rest of the article, most blatantly in paragraphs 5 and 8.

> The output of a foundry in tons of castings tells us little about its contribution to human progress. But sales dollars and profit give a measure we can recognize and interpret in terms of benefits to owners and employees.

Sales dollars and profit are a measure of benefit to stockholders only, interests of the employees and the public notwithstanding. We submit that the output in tons of casting is a measure of productivity and *hence* a contribution to progress.

> Boss Kettering goes a step further and speaks of the double profit system. In his view the customer should profit equally with the seller in any business transaction. Any other system is no better than a racket.

Boss Kettering's observation is true and points up a fallacy in paragraphs 2, 3, 5, and 8. Yet even Kettering ignores the duty of the firm to the employees. He should go one step further and admit that if the employee does not profit, the system is still no better than a racket.

> An engineer is called upon to apply his thoughts and energies to ideas and things, rather than to people and money which are the province of management. His experience has therefore conditioned him to look upon a foundry primarily as a place where things are made—and an engineering department as a place where ideas are translated into things.

Admittedly, the experience of the engineer has conditioned him to look upon a foundry primarily as

APPLYING RELIANCE V*S DRIVES IN CYCLING EQUIPMENT

BY
V. R. MURPHY, E.E.
Manager of V*S Products
Reliance Electric and
Engineering Company

Years of application experience have proved Reliance V*S Drives are ideal for powering cycling equipment. The all electric design is fast acting, acceleration times in tenths and hundreds of a second are common. V*S equipment lends itself to a variety of automatic controls.

V*S DRIVE COMPONENTS

A V*S Drive operates from standard a-c. power lines and consists of three basic components: d-c. drive motor, packaged motor controls and operator's control station.

Reliance drive motors change speed over a wide range, smoothly and without speed steps. The all electric design permits the inclusion of built-in dynamic or regenerative braking, giving fast, maintenance-free stopping power.

Motor-generator sets or electronic rectifiers, working from in plant a-c. power lines, form the nucleus of the motor control unit. A series of built-in controls regulate voltage and current in the system. With these controls, any required combination of speed, horsepower, torque and time characteristics are produced.

CYCLING WITH TENSION CONTROL

An example of simple, rapid cycling is shown in Figure 1. This is the operating cycle of a small winding machine that rewinds wax paper and similar material from large production rolls onto smaller rolls for retail sale. The operation requires a fast winding speed, as well as a slow speed for changing retail rolls. After the new roll is started, the productivity of the machine depends on how fast it can get to winding speed without tearing the material.

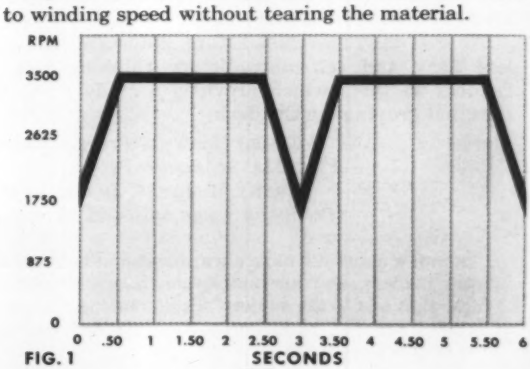

FIG. 1

A Reliance VST Control is used to force motor voltage to give optimum acceleration and deceleration rates. Selected rates can be designed into equipment to meet any cycling requirement. A description of this machine is found in Bulletin D-1532.

FORWARD AND REVERSE CYCLING

Another type of cycling operation is shown in Figure 2. This shows the cycle pattern of a flying cut-off on a continuous pipe mill. A V*S Drive automatically, measures the pipe length, starts the cut-off carriage and brings it to line speed, stops after cut-off and returns the carriage for another cut.

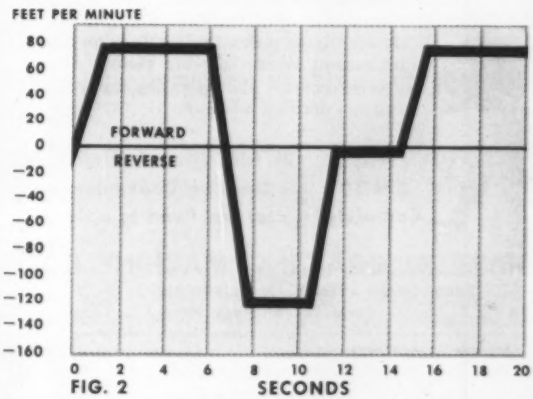

FIG. 2

A digital counter measures the pipe as it passes through the carriage. When the correct length has been fed through, the motor is forced and rapidly accelerated, bringing the carriage up to line speed. Using a dual tachometer matching system and a VSR speed regulator, the carriage speed is exactly matched to line speed during cut-off. After cut-off, the carriage is returned to its starting position, while the counter measures for another cut. A description of this drive is found in Reliance Bulletin L-2505.

These are two of the many types of cycling operations that utilize Reliance V*S Drives. The variety of Reliance V*S Controls, and the wide horsepower and speed ranges, make these drives applicable to any cycling operation. Cycling is only one operation for which the V*S concept is suited.

If you would like further information on how you can use V*S Drives when designing your product, contact your local Reliance representative, or write to the V*S Product Department. D-1581

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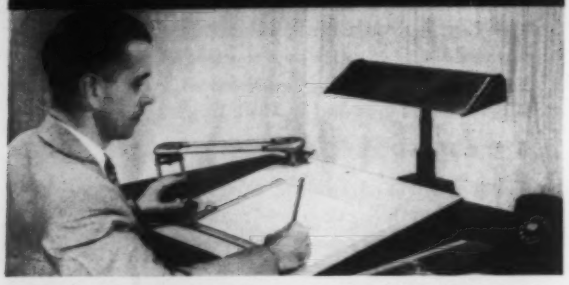

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Professional Viewpoints

a place where things are made, and he is right! It is a basic tenet of the free enterprise system that profits will be made by economically supplying human needs. The primary goal of business is to supply needs, since only in this way can it be a true success. However, if a business makes money but fails to supply needs economically, it is, in Boss Kettering's words, "a racket."

> It should never be forgotten that even the most benevolent and altruistic management—in foundries and everywhere else—is solidly dedicated and committed to making money. The most successful managements are the ones that make the most money for the most people.

Of course, they are committed to making money, but to say that "the most successful business is the one which makes the most money for the most people" is to equate money-making with success. In so doing it is forgotten that "money is a yardstick by which much that we value is measured" as you so nobly quoted in paragraph 4. The concept that money is all important is far out of perspective, and borders on deification.

> An engineer's value to his company, of course, is proportional to his alignment with that viewpoint. So is his effectiveness as a professional serving the public.

These statements are truly insidious ones and disregard all facts. Anyone with even a passing acquaintance with successful engineers and scientists, or the history of their achievements, realizes that their motivation is very seldom, if ever, monetary. The statements in this paragraph are at best made in ignorance. At worst they are an attempt to coerce the engineer into following blindly the dictates of management by telling him that the only duty he need consider is that of making money for the owners and that he should forget attempts to forward human progress.

As to the title of the editorial, "Management's Responsibility," we maintain that the responsibility of management is threefold: To the general public, to the employees, and to the investors, *in that order*. To satisfy the investors at the expense of the employees and the public is to ignore two primary responsibilities and approaches barbarianism. Let only those managements exist which first fulfill their obligation to their employees and to the public, and *then* to the investors. Any other approach to management has no place in a civilized society.

It is highly regrettable that your magazine does not provide any space for letters to the editor. Surely you are aware of the advantages of "feedback" in all communication systems.

We can only hope that future editorials will exhibit less hazy and self-contradictory thinking than the October 17 piece which provided a study in shallowness and gropings in the dark.

—James Browne, *Project Engineer*
—Fred Matin, *Senior Project Engineer*
—Frank R. Jones, *Junior Engineer*
(Company name withheld by request)

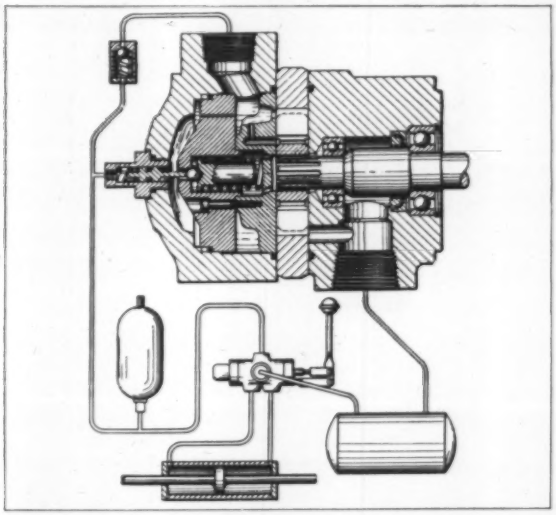
Editor's note: We have always welcomed comments from readers, and are more than happy to publish those that add to the subject. The foregoing and other letters prompted the Editorial which appears on Page 107 of this issue. ED.

NOTEWORTHY

Patents

Pump-Valve Combination

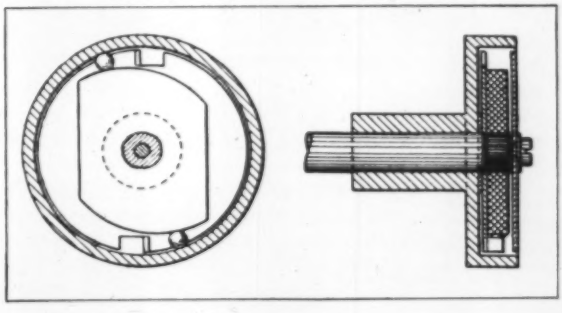
Incorporating a built-in unloading valve, a vane-type hydraulic pump requires near-zero drive power during periods of zero-demand operation. Shown here



in a typical hydraulic circuit, the pump remains unloaded until the external accumulator pressure is reduced to a predetermined value. Use of the integral unloading valve permits compact design and reduces plumbing requirements. *Patent* 2,809,588 *assigned to Vickers Inc. by Phillip G. Stewart.*

Quick-Acting Coupling

Quick action of an overrunning coupling, shown here connecting coaxial input and output shafts, is accomplished by use of a permanent-magnet rotor to position the locking balls. Because the magnetic field between rotor cam surfaces and the cylindrical flange ring is strongest at the points where the gaps are smallest, the locking balls are held in close contact

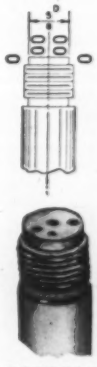


The Lepel line of induction heating equipment represents the most advanced thought in the field of electronics as well as the most practical and efficient source of heat yet developed for industrial heating.

If you are interested in induction heating you are invited to send samples of the work with specifications. Our engineers will process and return the completed job with full data and recommendations without any cost or obligations.

TYPICAL INDUCTION HEATING APPLICATIONS

HARDENING DIESEL FUEL INJECTOR

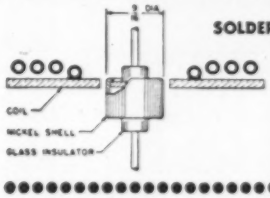


Restriction of heat to end of holder body for fuel injector permits hardening of face to provide required resistance to deformation without hardening the threads. Coil design shown provides uniform temperature for hardening despite holes in face.

REMOVING RUBBER FROM STEEL

Induction heating develops uniform temperature at steel-rubber interface destroying bond for easy separation. Steel and rubber may similarly be salvaged from mounting brackets, shock absorbers, etc.

SOLDERING TRANSISTOR ASSEMBLIES



Concentrator-type coil creates high intensity, restricted heating at joint of nickel shell and tinned glass, thus causing solder flow for permanent seal.

Electronic Tube Generators from 1 kw to 100 kw.
Spark Gap Converters from 2 kw to 30 kw.

WRITE FOR THE NEW LEPEL CATALOG . . . 36 illustrated pages packed with valuable information.

All Lepel equipment is certified to comply with the requirements of the Federal Communications Commission.

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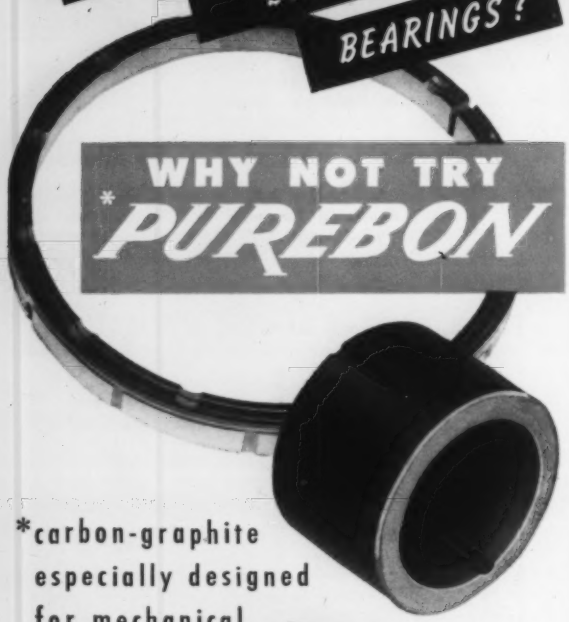
55TH STREET and 37TH AVENUE, WOODSIDE 77, NEW YORK CITY, N. Y.

Circle 543 on Page 19

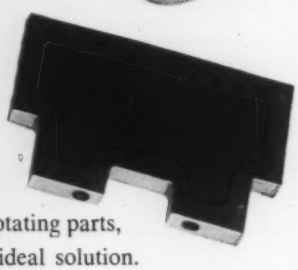
DO YOU HAVE A LUBRICATION PROBLEM ON...

SEAL RINGS
BLADES
BEARINGS?

WHY NOT TRY *PUREBON



*carbon-graphite especially designed for mechanical applications



Where lubrication is a problem on bearings, seals, blades and similar sliding or rotating parts, **PUREBON** is often the ideal solution.

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1. Stable at high temperatures. 2. Moldable to size. 3. Light weight. 4. Low cost where moldable to size. 5. Readily machinable. 6. Chemically inert.

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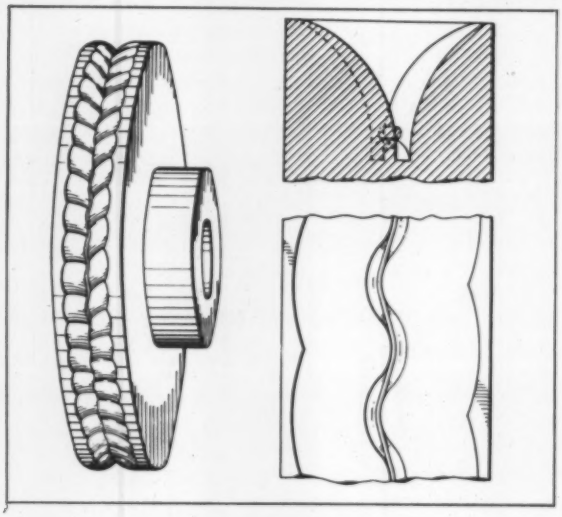
PURE CARBON CO., INC.
442 HALL AVENUE
ST. MARYS, PENNSYLVANIA

Noteworthy Patents

with the driven ring, regardless of the direction of rotor rotation. Clockwise rotation of the driving rotor therefore wedges the balls and couples the shafts with minimum free play. *Patent* 2,804,184 *assigned to Haldex Aktiebolag (Sweden) by Bengt Anders Bjork.*

Nonslip Pulley

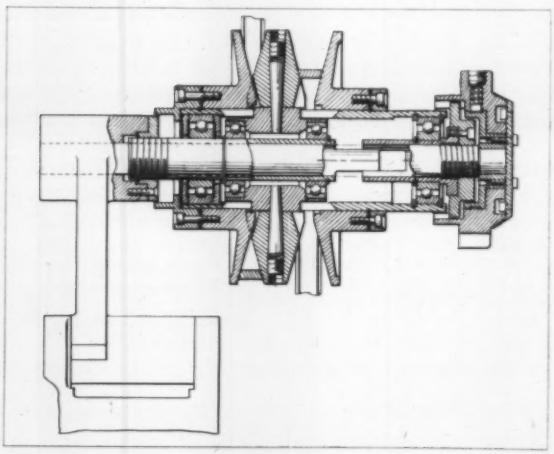
Threads or fibers are transported without slippage by a pulley designed for use in textile machinery. Facing pulley halves, which are axially adjustable,



define a wavy groove through which the thread runs without snagging or clamping. Groove width can be adjusted to suit the thread diameter. In larger sizes, unit is suitable for use in rope-transmission drive systems. *Patent* 2,802,366 *assigned to American Enka Corp. by Christian Borner.*

Adjustable-Speed Transmission

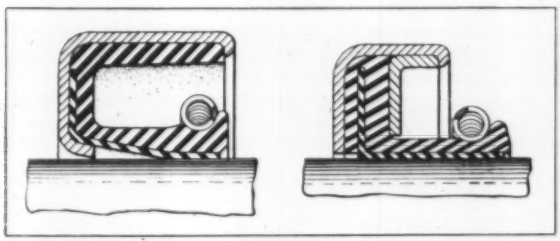
Compensation for changing center distances of driving and driven V-belts is automatically provided by the swing-arm mounting system of an adjustable-



speed transmission. As handwheel (right) is turned in the speed-increasing direction, both pulley-sheave halves move left, forcing the driving belt (right) outward to a larger radius and the driven belt (left) to a smaller radius. Swing arm, on which the speed-adjusting assembly is mounted, revolves around the mounting hub (lower left), providing compensation for changing V-belt center distances. *Patent* 2,755,676 *assigned to American Type Founders Co. Inc. by Jens M. Jepsen.*

Teflon-Sleeved Radial Seal

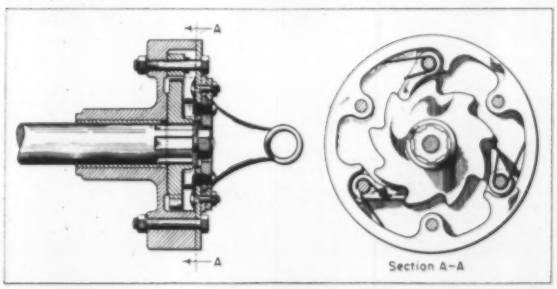
Extreme-pressure oils with high sulphur content have little effect on a radial seal incorporating a Teflon wearing sleeve. Sealing contact of the sleeve



with the shaft is provided by a resilient rubber backing element. Because Teflon operates with low friction coefficient against the shaft, seal temperatures are low, and the deteriorating action of lubricants on rubber seal elements is greatly retarded. *Patent* 2,804,324 *assigned to General Motors Corp. by John A. Stallings.*

Overrunning Torque-Limiting Coupling

Torque transmitted through an overrunning coupling is limited to preset values by easily replaceable shear pins. Overrunning action, accomplished by



pawl-and-ratchet design, protects prime mover from damage by high-inertia loads. Typical application is for coupling farm implements to a tractor power-takeoff shaft. Shear pins protect prime mover from damage in the event of abrupt load pickup; overrunning clutch allows load to freewheel when power is suddenly reduced. *Patent* 2,803,325 *assigned to J. I. Case Co. by Howard E. Wiltsey.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

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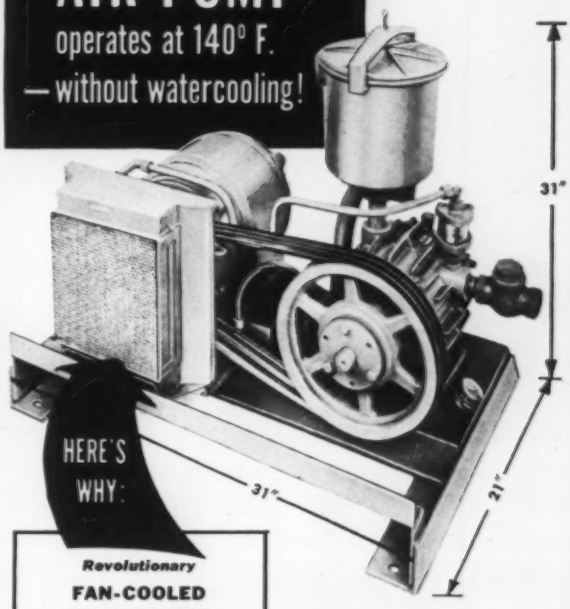
operates at 140° F.
—without watercooling!

VACUUM: to 29.9" Hg.

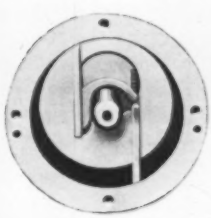
CAPACITY: to 40.8 c. f. m.



Revolutionary
FAN-COOLED OIL RADIATOR
(Patent Approved)
continuously circulates pre-cooled oil through pump, reduces heat on pump parts, prevents overheating and jamming. Oil provides seal for vacuum. Permits speeds up to 800 r.p.m., provides greater capacity with smaller pump.

- No water pipes—no leaks—place pump anywhere
- No oil vapor
- Rugged—for 24-hour continuous operation, without overheating
- Every pump performance-tested before shipment

You don't need bulky, high-priced air pumps and complicated water pipe hookups to produce continuous high vacuum. Leiman engineers have the answer in a compact package . . . the oil-cooled Leiman High Vacuum Pump. Run it 24 hours a day—it maintains an average temperature of 140° F. Run it year after year—it maintains fully rated capacity, without troubles or shutdowns, because it features the



"Lifetime" Leiman 2-Wing Vacuum Pump with Patented Wing Adjuster

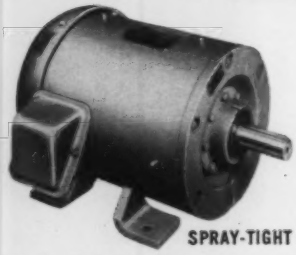
Precision-honed cylinder walls are made of durable cast iron; wings are made of wear-resistant steel (not composition). Automatic wing adjuster assures constant wing-to-wall contact, prevents sticking or binding. Pump takes up its own wear to provide maximum vacuum for years.

WRITE for latest 16-page catalog describing complete line of Leiman Vacuum Pumps, plus Application Book of "how-to-do-it" blueprints.

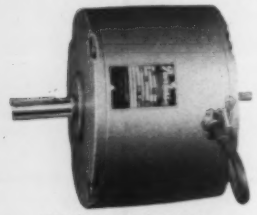
LEIMAN BROS, Inc.
158 Christie St. Newark 5, N. J.
Established 1887

Circle 545 on Page 19

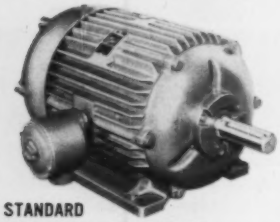
ONLY ONE MOTOR IS RIGHT FOR YOUR APPLICATION...



SPRAY-TIGHT
Fan cooled; 7½ HP; Navy; Hi-shock to Navy Spec. MIL-M-17060A.



TOTALLY ENCLOSED
Blower and Drive Motor; 4 HP; air drawn over motor.



STANDARD EXPLOSION-PROOF MOTOR
1 to 30 HP; also with NEMA C face and NEMA D flange.

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Motor to fit customer's application design.

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FREE SELECTION CHART for AGASTAT® time delay relays

Now you can select exactly the right Agastat time delay relay for your particular timing need—in a hurry. This free selection chart lists data on every popular model in the Agastat line—the most complete line of pneumatic time delay relays in the industry. They're adjustable for timing from 0.1 second to 10 or more minutes, unaffected by voltage variation, dust-proof, light, and mountable in any position. And there's an Agastat model to precisely fit your requirements, including two-step, electrical interlock and double head units. A glance at the free selection chart tells you which model to order.

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AGA DIVISION
Elastic Stop Nut Corporation of America
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Pioneers in pneumatic timing.

Circle 547 on Page 19

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■ WILBOW silicone rubber parts have many desirable characteristics in addition to excellent stability under temperature extremes (−125° to +600° F). Silicone may be the answer to your problem if your parts require low compression-set, good dielectric properties, resistance to ageing, sunlight or ozone, exceptional release from sticking or other characteristics not commonly found in natural rubber or other synthetics.

We are well experienced in producing silicone parts by techniques such as molding, extruding, calendering, bonding or punching from sheet. Let us know of your requirements.

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Mfrs. of molded, punched, extruded and cut rubber goods. Specialists in producing rubber covered rolls, silicone rubber parts and bonding rubber to metal

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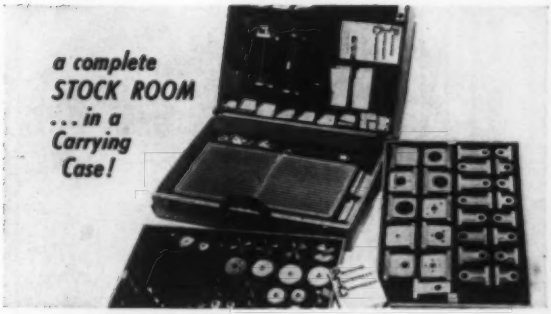

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Why NEW Parker floats are better than cork or metal

Better than cork. Lighter than cork . . . can be used in higher temperatures. Need no protective coat, yet are resistant to fungus and won't waterlog, thus maintaining stable weight and volume.

Better than metal. Can't rust or corrode . . . won't fail from punctures or vibrations.

Can be machined or drilled to your specifications.

Where can you use them? In all types of aviation and jet fuels, oil, water, many other liquids. Molded to your particular needs. Send for catalogs No. 5810 and No. 5870.

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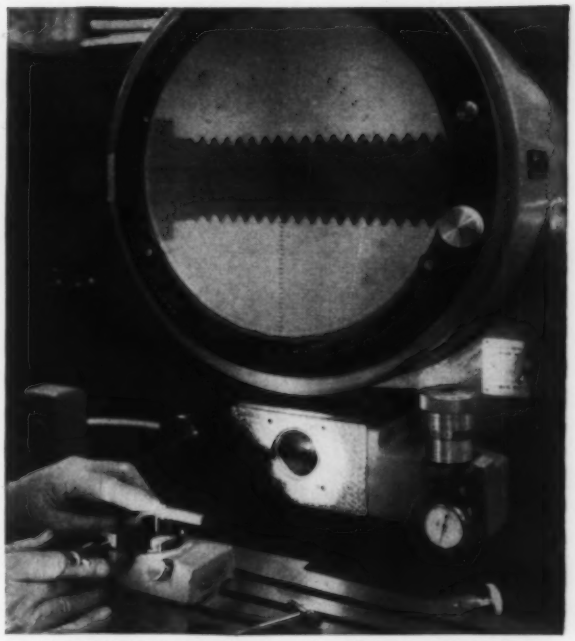
Parker Hannifin
creative leader in fluid systems

Parker Rubber Division, Section 529-V, Parker-Hannifin Corp., 1538 South Eastern Ave., Los Angeles 22, Cal., or 17325 Euclid Avenue, Cleveland 12, Ohio.

Circle 550 on Page 19



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For that truly "finished" appearance specify

Bristol Socket Cap Screws

Bristol socket cap screws add the crowning touch to the craft of a master machinist.

Whether it's a jig, fixture, precision tool, or the final product itself, these cap screws give you more than just holding power.

Diamond knurled heads highlight the care we take in producing these screws, make for easy handling and a pleasing appearance.

Precision cut threads (in NF and NC, Class 3A fit) allow these screws to spin easily into place, fit perfectly, wrench up tightly.

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See your industrial distributor for all the facts on these quality cap screws for your quality products. Available in alloy steel and stainless. Flat-head cap screws, centerless-ground shoulder screws, pipe plugs, set screws also available in the most complete line on the market. A.6.33

Precision socket screw manufacturers since 1913

*Made in sizes as small as No. 0 in Alloy Steel and Stainless Steel. Cap Screws up to 1½"

THE BRISTOL COMPANY, Socket Screw Division, Waterbury 20, Conn.

Circle 551 on Page 19

smartly designed part saved by cold heading

Functionally the design of the above part was ideal. But its six different diameters and the need to pre-assemble a fibre washer posed production difficulties. Making it by conventional machining methods would price it out of reach. It looked too complex for cold heading.

But Progressive did it. We can apply cold heading to components normally considered as machining jobs, which would naturally cost more. You, too, can save money on difficult parts. For more case histories, write for our *"Bank Book of Savings in Cold Heading."*

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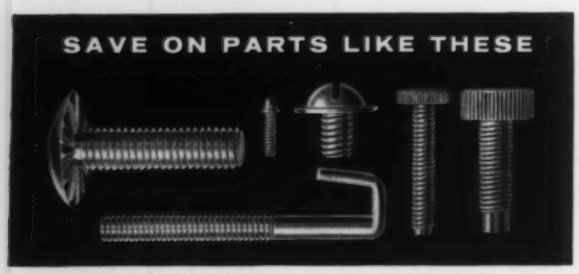
THE PROGRESSIVE MFG. CO.

Division of The Torrington Company

52 Norwood St., Torrington, Connecticut



AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

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COMPACTNESS

● Features an insulated rocker arm activated by a single coil, instead of the usual two. Ideal for machine controls, appliances, positioning devices, remote TV controls and other applications where opposite switching is desired each time the circuit is pulsed. Contact combinations up to 4 "C"; rated 7½ amperes @ 115 V. AC resistive.

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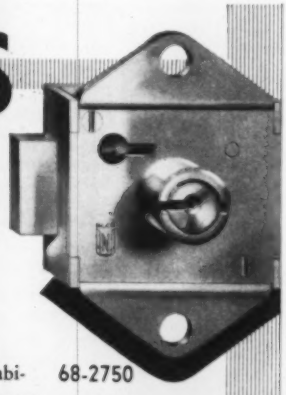
LOCKS by National Lock



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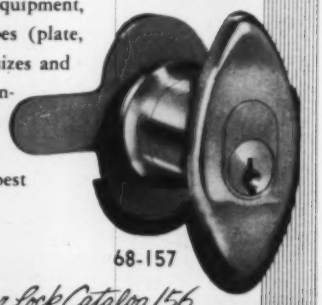

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Write for Lock Catalog 156

NATIONAL LOCK COMPANY
Rockford, Illinois

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Circle 554 on Page 19

now presenting . . .

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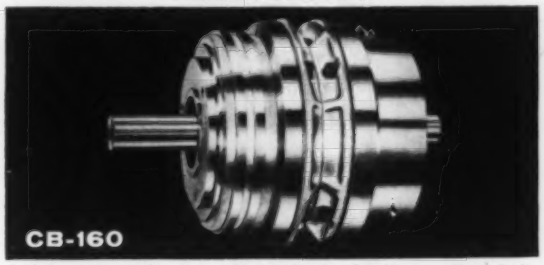
LARGER SIZES CLUTCHES & BRAKES

Diameters 4" to 12½"



5 Styles • Clutch Coupling • Electric Clutch • Combination Clutch-Brake Electric Brake • Duplex Clutch

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1 Simple Design—exclusive diaphragm is only moving part, obsoletes conventional clutch or brake made up of numerous troublesome parts.

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Representation in Key Industrial Areas

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Identical ends of the Type "U" DRIV-LOK Pin have a short pilot which permits easy insertion of *either end* into the hole. Result: Type "U" Pins can be fed automatically, or, because the operator need not examine the pin before insertion, manual feeding is faster and easier. Full length parallel grooves provide maximum locking effect. Typical applications include keying gears, collars, knobs, handles to shafts.

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DRIV-LOK PIN COMPANY

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Circle 556 on Page 19

that's right!

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rubber parts resist temperatures from -160°F. to +600°F.

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Stalwart engineers will work closely with you to produce Silicone parts to meet your most exacting specifications. For special applications, Stalwart can supply fabric-inserted shapes. Silicone shapes also can be covered with Nylon, Dacron, Orlon and fiberglass. Parts can be supplied in realistically-priced production or job-lot quantities.

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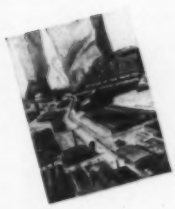

STALWART RUBBER COMPANY

Main Office:

180 Northfield Road, Bedford, Ohio

Manufacturing plants in Jasper, Georgia and Bedford, Ohio

7846-SR

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"MONOBALL" Self-Aligning Bearings

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CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
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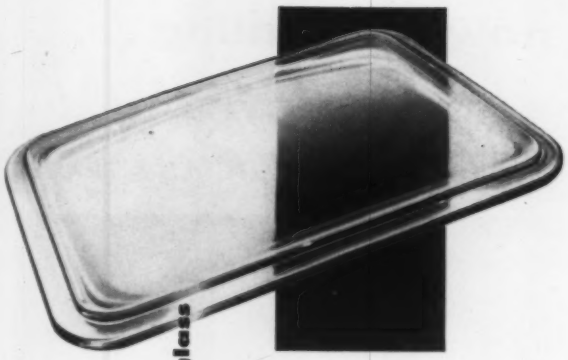

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Lancaster
glass and plastics
to brighten your product's future

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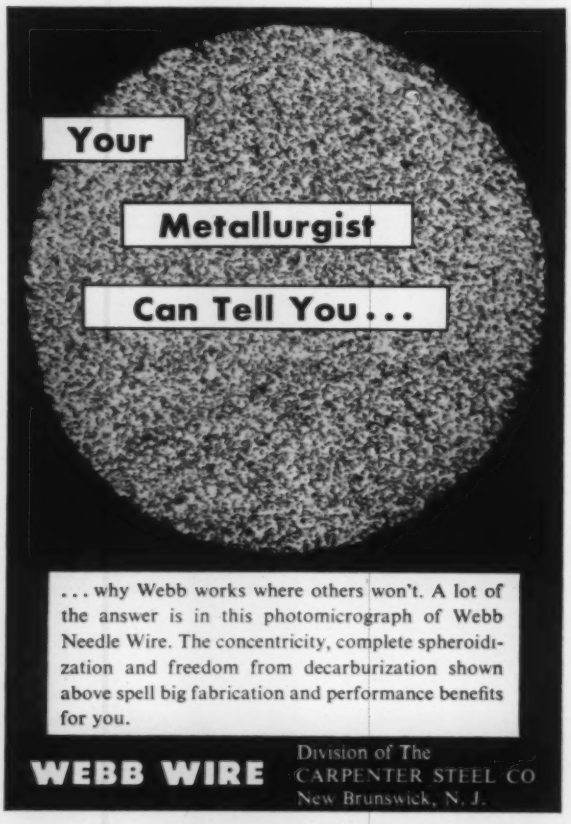

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WEBB WIRE Division of The CARPENTER STEEL CO New Brunswick, N. J.

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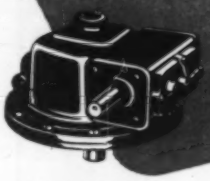
Abart precision-built

Speed Reducers



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Write today for Abart's free data-packed, pocket-size speed reducer catalog.

ABART GEAR and MACHINE CO.

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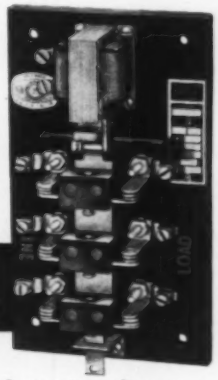

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Send today for free bulletin.

See classified telephone directory for local distributor.

ZENITH ELECTRIC CO.

149 W. WALTON ST. • CHICAGO 10, ILL.

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To Your DESIGN SPECIFICATIONS - From the Hand of the Specialist . . .

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Bolts • Studs • Cap Screws • Nuts in Alloys • Stainless • Carbon • Bronze

Experienced hands . . . expert hands . . . hands grown competent by 45 years of the finest precision work. These are the hands of our specialists who meet your design and engineering specifications. Special Erie fasteners to meet the rigors of extreme temperatures, corrosion, tensile stresses are serving widely diverse industries the world over. Send your specifications to us, confident of the finished precision fasteners you expect.

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Representatives In Principal Cities

Circle 563 on Page 19

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ELECTRICAL ENGINEERS

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If you are interested, send full details of your engineering background to the Editor, MACHINE DESIGN, Penton Building, Cleveland 13, Ohio.

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Can specialized business publication advertising actually sell?

By reputation, salesmen are reluctant to credit anything but their own selling efforts for getting names on the dotted line.

Actually, it's quite a different story. The most successful salesmen will tell you two important things about selling. 1. That the selling process is largely a matter of communicating ideas. 2. And that specialized business publication advertising can help importantly to register information with prospects.

Of course each salesman will express this in his own way . . . but they all agree that selling would be far more difficult without the advertising that appears in the industrial, trade and professional publications that serve the specialized markets to which they sell.

Here, for instance, is what a salesman has to say about this kind of advertising:

Fred Snyder, Cleveland District
Worthington Corporation

sells to industry

Says Mr. Snyder:

"We have, of course, sales leads from our business paper advertising that are forwarded to us on a monthly basis. But also the trade advertising has its impact on many who do not at the time request specific information. Worthington is far better known today than it was five years ago, due in no small measure to the aggressiveness of its advertising and sales promotion department.

"Their work makes my job easier. First of all, we have an entree in companies where some Worthington products were not previously as well-known as our original line. We're getting a lot better sales coverage on all products. The Corporation manufactures so many products today that even regular customers may be unfamiliar with some of these products. Through trade advertising and sales promotion we have been able to sell the whole Worthington line.

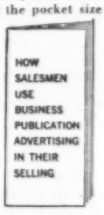
"Getting back to sales leads—they are particularly helpful to our dealers. In Cleveland, W. M. Patterson Supply will undoubtedly receive inquiries from Worthington's advertising. Scott-Tarbell, Inc., Cleveland Oak Belting, or other dealers handling special product lines will pick up leads from our advertising to help them get business.

"I think we've grown eightfold since the war. This year we hit two hundred million. It used to be that twenty-five million was a good year. The advertising and sales promotion department has aggressively been attacking their part of the problem within the last five years. Prior to that the name Worthington was not nearly so well-known and we put much less emphasis on advertising."

Ask your own salesmen what your company's business publication advertising does for them. If their answers are generally favorable you can be sure that your business publication advertising is really helping them sell. If too many answers are negative it could well pay you to review your advertising objectives—and to make sure the publications that carry your advertising are read by the men who must be sold.

How salesmen use their companies' advertising to get more business

Here's a useful and effective package of ideas for the sales manager, advertising manager or agency man who would like to get more horsepower out of his advertising. Send for a free copy of the pocket size booklet entitled, "How Salesmen Use Advertising in Their Selling," which reports the successful methods employed by eleven salesmen who tell how they get more value out of their companies' advertising.



You'll find represented many interesting variations in how they do this. Some are very ingenious; all are effective. You can be sure that more of your salesmen will use your advertising after they read how others get business through these simple methods.

The coupon is for your convenience in sending for your free copy. Then, if you decide you want to provide your salesmen with additional copies, they are available from NBP Headquarters in Washington, at twenty-five cents each. Or, if you choose you can reprint the material yourself and distribute it as widely as you please. But first, send for your free copy.

NATIONAL BUSINESS PUBLICATIONS, INC.
Department 2E
1413 K Street, N. W.
Washington 5, D. C. STerling 3-7533

Please send me a free copy of the NBP booklet "How Salesmen Use Advertising in Their Selling."

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Company _____

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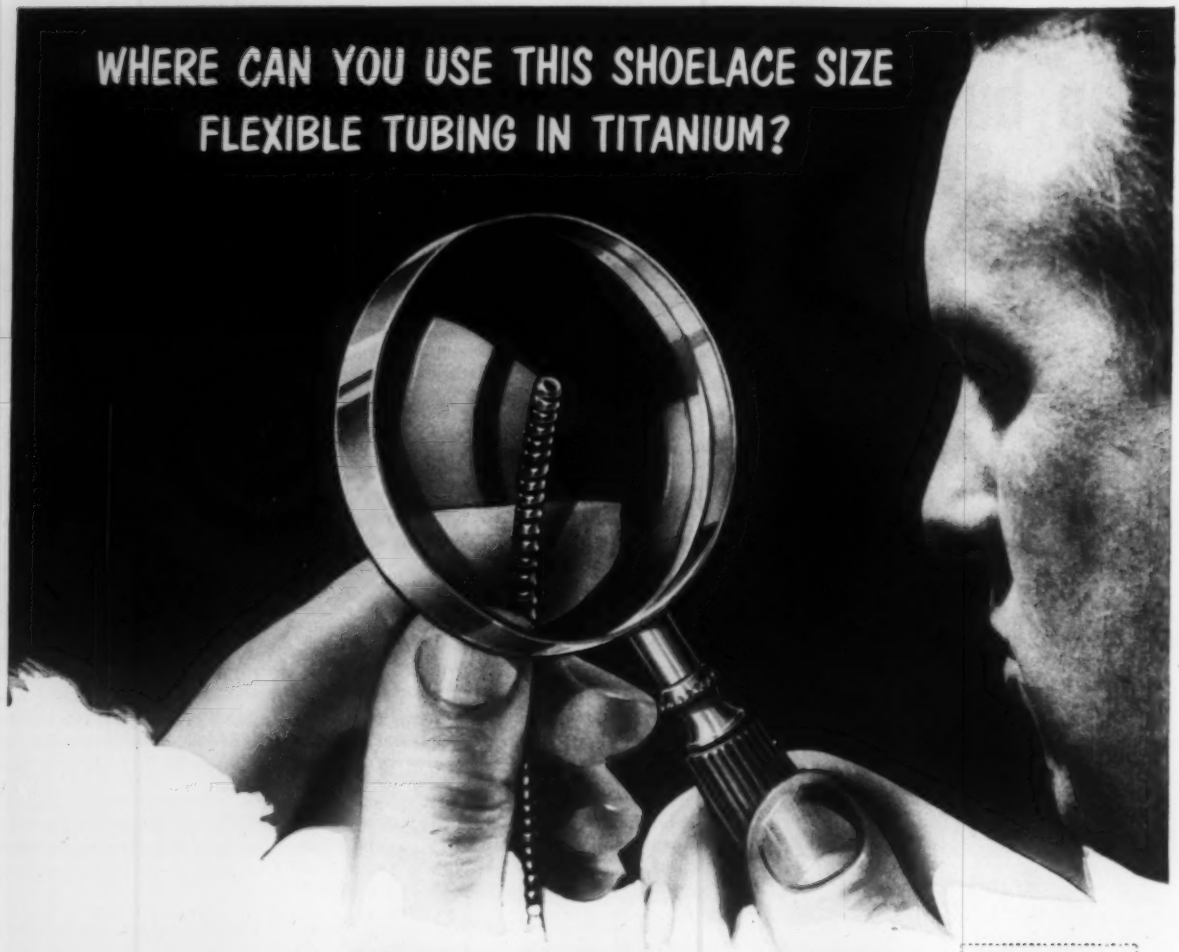
. . . each of which serves a specialized market in a specific industry, trade or profession.

WHERE CAN YOU USE THIS SHOELACE SIZE FLEXIBLE TUBING IN TITANIUM?



Flexon Rex-Tube Type RT-1

.050" I.D., .115" O.D. in TITANIUM or other metals

TWO MORE FLEXONICS FIRSTS

Size—.050" I.D. flexible tubing

Material—Titanium

Here in magnified cross section is the configuration of this special square locked Type RT-1 flexible metal tubing. In addition to titanium, it is available in stainless steel, brass or bronze.

Here is an unusual product that may answer a need of yours. Frankly, we don't know. It was developed as a result of an "impossible" request. Our customer needed a tiny titanium control wire casing for a classified project so we can't even tell you where it is being used. But if you have a use for a remarkably small flexible tube or capillary casing, this, or a modification, could solve your problem and we'd like to talk to you about it.

As headquarters for flexible metallic products, Flexonics Corporation is often called upon to do the "impossible". Experience, know-how and facilities make Flexonics the most logical source for answers to these problems. If you have such a need, we'd like to go over it with you, no matter how "impossible" it may sound.

FLEXON

THE FIRST NAME IN MOTION CONTROL

X-4

9 plants to serve you in the United States and Canada

Flexonics Corporation

INSTRUMENTATION DIVISION

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In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

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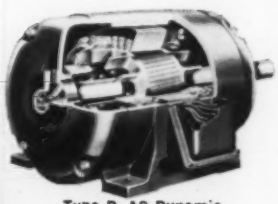
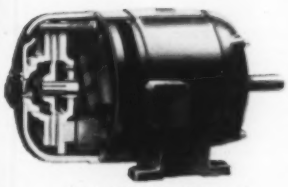


Type D, AC Dynamic

ROLLING STOP...Master Type D Dynamic Unibrake Motors. Braking is obtained with a unique, patented brake winding superimposed on the stator winding. Simple, compact, with no DC current required, the brake has no moving parts. There is nothing to wear or adjust... braking torque repeats consistently. Particularly recommended for automatic applications where static holding is not desired. Sizes ¼ to 30 H.P.

MASTER UNIBRAKE MOTORS



Type M—Magnetic

STOP-HOLD...Master Type M Magnetic Unibrake Motors. For quick, controlled stopping... especially when you want to hold the load. Spring-setting magnetic brakes of the friction disc type combine with motor in a compact, integral unit. Sizes... ⅛ to 150 H.P.

MASTER GEARMOTORS and variable speed drives can be furnished with Unibrakes, too. See Master for the perfect power drive for you.

THE MASTER ELECTRIC CO.

DAYTON 1, OHIO

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

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Name your bearing needs...we'll meet 'em pronto from 30 types, 10,247 sizes

TIME and time again, machinery makers come to the Timken Company for help with some special bearing application problem. One they think hasn't been solved before. And time after time, from our 30 types and 10,247 sizes of Timken® tapered roller bearings, we've come up with the bearing design to do the job and at minimum cost.

It's no accident that we can help out so often. In over 50 years of helping machinery builders with bearing problems, we've engineered and produced the world's largest selection of tapered roller bearings. And we've constantly improved our designs. The answers to thousands of bearing application problems are already in our files. Ready and available to help you.

And machine users get the same swift service if they ever need a replacement Timken bearing. Even for old machines, they can almost always count on immediate delivery of Timken bearings for replacement.

Why not call on our engineers for help whenever you have a bearing application problem or requirement? Timken is your No. 1 bearing value. Wherever wheels and shafts turn, Timken bearings eliminate friction, cutting wear and maintenance to a minimum. Specify bearings trade-marked "Timken" for the machines you buy or build. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

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